ECORE
INTERNATIONAL ASSOCIATION FOR RESEARCH AND TEACHING
Economics, Finance, Operations Research, Econometrics and Statistics

++ research ++ teaching ++

ECORE DISCUSSION PAPER

2010/42

The Quality Factor in Patent Systems

Bruno VAN POTTELSBERGHE DE LA POTTERIE

CORE
Université catholique de Louvain

ECARES
Université Libre de Bruxelles

The quality factor in patent systems[↑]

Bruno van Pottelsberghe de la Potterie[ab]

[a] Université libre de Bruxelles (U.L.B.), Solvay Brussels School of Economics and Management (SBS-EM), ECARES. Brussels, Belgium

[b] Bruegel, Brussels.

May 2010, First Draft

Comments warmly welcome

Abstract: This paper puts forward a new methodology that aims at comparing quality across patent systems. Quality is defined as the extent to which patent offices comply with the legal standards that rule patentability conditions (novelty, inventiveness, transparency). The methodology consists in a two-layer analytical framework composed of "legal standards" and their "operational design". Operational designs include several elements that frame the rigour and transparency of the filtering processes. The in-depth analysis of these two layers for the patent offices of the USA (USPTO), Japan (JPO) and Europe (EPO) lead to the following conclusions. The operational designs' components are interdependent and form a coherent system. This systemic approach underlines that if legal standards are similar across countries, their operational design are heterogeneous. The empirical evidence suggests that the EPO provides higher quality services than the USPTO, the JPO being in an intermediate position. These differences call for a multi-faceted convergence of patent systems before worldwide mutual recognition and work-sharing practices are to be put in place.

JEL Classifications: O30, O31, O34, O38, O57

Keywords: patent system, quality, patent propensity, intellectual property.

[↑] Earlier drafts of this paper were presented at the Innovation Forum seminar (Hitotsubashi University, Institute of Innovation Research, 5th February 2010), the EPO internal seminar (18th of March 2010, The Hague) and at the BDI Conference (Bundesverband des Deutschen Industries, "Tag des geistigen Eigentums", enforcement and quality in patent systems, Berlin, 26 April 2010). I would like to thank the participants to these seminars for their remarks and comments. In particular, J. Danguy, G. de Rassenfosse, M. Mejer, N. Stevnsborg and Nicolas van Zeebroeck provided helpful suggestions for improvements.

1. Introduction

Over the past decades patent offices worldwide have faced continuous increases in patent filings, which induced so-called backlogs: ever growing stocks of applications pending longer in examination stage, therefore generating uncertainty on the market. This generalized trend led the largest patent offices worldwide to enter into collaborative projects, which essentially aim at sawing the seeds of international work sharing and mutual recognition practices. The ultimate outcome would be that the work performed by a patent office A would not be duplicated in other patent offices, thereby saving time and resources. This global convergence process is *a priori* welcome, especially if it contributes to improve efficiency.[1]

It must however be noticed that if an inflationary trend occurs in all large economic areas, there are noticeable differences across countries. The situation is actually more dramatic in the USA than in Europe or Japan. The United States Patent and Trademark Office (USPTO) faces both a record number of yearly patent applications and the most impressive backlog. At the opposite is the European Patent Office, with the smallest backlog and number of filings. Japan is in an intermediate position. In their in-depth investigation of the US patent system, Jaffe and Lerner (2004) raised the hypothesis of a vicious cycle. A low quality examination process would lead to the filing of more low quality applications, which in turn would further reduce the examination quality through overloaded examiners. This "vicious cycle" hypothesis could as well explain the observed structural differences amongst the three major patent offices: different designs of patent systems would lead to different outcomes in terms of backlog and patent propensity. In order to validate this hypothesis, internationally comparable indicators of quality must be created. And to the best of our knowledge, the quality factor in patent systems has not, or at most partially, been tackled in the economic literature.

The objective of this paper is to develop a new methodological framework to assess quality in patent systems. The research intention is to identify the extent to which patent systems differ in their "delivery" or "quality" of patent examination services. Quality is defined as the extent to which a patent system complies with its legal standards in a transparent way. The methodology consists in characterizing patent systems with a 2-layers analytical framework. The first layer is composed of "legal standards" which include the selection of patentable subject matters, the novelty condition, the required degree of inventiveness, and the fee schedule. Two legal standards, fees and the definition of patentable subject matters, are easy to measure and compare across countries. However, most countries have very similar "novelty" and "inventiveness" conditions. For these two legal standards differences can only be observed in their implementation. A second layer is therefore composed of the operational design put in place to

[1] Since 2008 The USPTO has signed many Patent Prosecution Highways (PPHs) agreements with Japan, the UK, the EPO and other patent offices, which have also entered into other bilateral agreements. These agreements essentially aim at work- sharing and mutual recognition processes between patent offices. Under the PPHs each patent office agrees to exploit the work previously done by other patent offices and fast-tracks the examination of the corresponding patents.

comply with each legal standard. Operational designs include several elements that frame the rigour and transparency of the examination processes. The extent to which operational designs differ across countries may ultimately lead to different degree of rigour and transparency in patent selection processes. The methodology is applied to three major patent offices: the USPTO, the JPO and the EPO.

Through its objective and methodology the present paper contributes to bridge two important gaps. First, quality has not been investigated as such in the economic literature devoted to the analysis of patent systems. Several dimensions of patent systems have been thoroughly investigated (e.g., the length, breadth, scope, or fees), but quality as a whole has not been tackled. It is worth mentioning that this paper is not about whether a stringent patent system is good or bad for the economy, but on assessing the extent to which quality varies across countries. Second, the paper contributes to bridge a wide gap between on the one hand the complex world of patent professionals (examiners, attorneys and experts) and on the other hand the world of policy makers, research scholars and potential users. Patent systems are complex because they are at the interface between legal constraints, economic incentives, scientific and technological advance, and business strategy.[2] At the opposite is the practice that consists in overly simplifying the examination practice to abstract concepts like patent "breadth" or "scope", which are nearly impossible to implement in day-to-day practice. By identifying the most important elements of two key legal standards' operational design, the paper puts forward a fair balance between complexity and abstract simplification.

The paper is structured as follows. The next section presents the research motivations, namely the extent to which backlogs take place, and identifies their potential causes and consequences. Section 3 summarizes the economic literature on patent systems and analyse how they have been gauged so far. Section 4 presents the 2-layers analytical framework put forward in this paper: the four legal standards and the components of their operational design. Section 5 compares the three offices along this 2-layers analytical framework. Section 6 concludes and draws policy implications.

The in-depth qualitative analysis of the operational designs put in place to fit the legal standards that rule patentability conditions lead to two main conclusions. First, the operational designs' components are interdependent and form a coherent system. It is therefore recommended to adopt a systemic approach when assessing the effectiveness of patent systems. Second, quality varies to a significant extent across the three patent offices. The results underline a relatively low quality or rigor of the novelty and inventiveness conditions in the US, especially when compared with Europe. Japan is in an intermediate position. These quality differences have implications for the current attempts to evolve towards a mutual recognition process between patent offices.

[2] See for instance the "Guidelines for Examination in the European Patent Office", published by the European Patent Office (2010), which contains nearly 600 pages of laws, rules, practices and exceptions.

2. Motivations: common trends but structural differences

Patent systems worldwide are characterised by a constant increase in the number and size of patent applications. At the EPO, the year 2008 saw record-breaking number of patent filings, about 226,000, an increase of more than 60 percent on 2000. Figure 1 shows that this is far from being an isolated issue, patent filings have been increasing in many countries over the past decades, which may be attributable to several factors (see Guellec and van Pottelsberghe, 2007):

- Higher levels of research and development (R&D) expenditures, fast-emerging technological fields (e.g., nanotechnologies, biotechnologies), and fast-growing countries. From less than 300 billion (in constant 2000 USD PPPs) in the early 1980s, the annual level of R&D expenditures in the OECD area increased to more than 750 billion in 2008. If countries such as China, Russia, Israel and Singapore are also accounted for, an additional 150 billion can be added (as compared to 50 billion in 2000);

- The ongoing globalization trend increases the propensity to file patents abroad. This is witnessed for instance by the fast growth of PCT applications at WIPO. Danguy et al. (2010) provide empirical evidence that the sharp increase in regional patent offices' applications (especially the USPTO and EPO) is essentially due to a more pronounced globalization factor (in other words, a larger share of domestic priority filings are transferred to foreign patent offices as second filings);

- New types of institutions entering the patent arena, like universities and young innovative companies (from less than 0.5 percent of total applications in the early 1980s, academic patenting now exceeds four percent) [3];

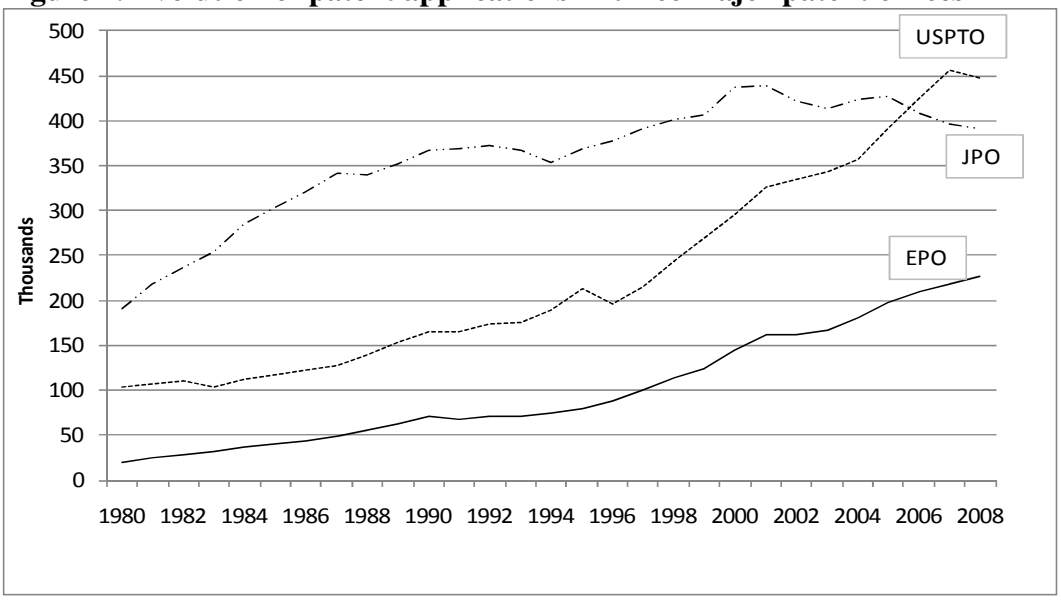
- New innovation management practices and patenting strategies are developed by the business sector. Institutions are not only more likely to seek protection for an invention, they are also protecting it with more than one patent. The patent-to-researcher ratio in the OECD area has more than tripled at the EPO, from 1.6 in 1980 to more than 5 patents per 100 researchers in 2008. In the US the ratio has less than doubled but was already much higher and has jumped from about 6 patents per 100 researchers 30 years ago to more than 10 nowadays[4]. New management practices have also improved the productivity of research, which translates into more patent applications per dollar of R&D. These practices are characterized by a new division of labour, whereby some firms specialise in research

[3] The Bayh-Dole Act of 1980 gave US universities greater incentives to commercialize technology: 'The act allowed universities to patent the results of federally-funded research and license the resulting technology to businesses and other entities' (Joint Economic Committee US Congress, 1999, p.31). European countries and Japan adopted similar legislations over the 90s. See for instance Geuna and Nesta (2007) and Lissoni et al. (2008) for recent empirical evidence for European countries. According to Mowery and Sampat (2004), this trend is also observed for the applications filed at the USPTO.

[4] Own calculations, based on patent series statistics and R&D expenses (OECD, MSTI, 2008).

activities and sell their research output to 'producing' firms. According to Kortum and Lerner (1999) the observed jump in patenting in the 1990s reflects an increase in US innovation spurred by improvement in R&D management practices[5]. Companies tend to change their management practice from a 'single-patent' approach to a portfolio approach, which is based more on quantity than quality. This practice may be attributable to tactics and motivations, well described in Arora et al. (2002), Guellec et al. (2007), and de Rassenfosse (2010) which are designed to 'reserve' or capture markets for technology.

Figure 1. Evolution of patent applications in three major patent offices



Source: Own calculations from annual report of the three patent offices. Applications at the EPO include EPO Direct-applications, and PCT international applications for which search reports must be performed.

- One additional explanation is related to the 'easiness' to have a patent granted, the concept of easiness being measured by the rigour and the cost of the patent selection process. This 'laxity of patent offices' hypothesis has been recently raised by a few scholars. Encaoua et al. (2006, p. 1430) for instance argue that the "*boom in patent applications* [*is concomitant with*] *a general sentiment of relaxation of patentability requirements* [...] *in certain*

[5] A more recent trend in innovation management is the so-called 'open-innovation' process (cf. Chesbrough, 2003) through which firms collaborate on innovative projects with other specialised firms in order to widen the scope of their knowledge base and to speed up their research and market reach. Opening its own knowledge base to others generally requires sound protection of your own intangible assets, which partly explains the need to rely more frequently on the patent system. For instance, Peeters and van Pottelsberghe (2006) show that three key dimensions of innovation strategy influence the size of a firm's patent portfolio: the relative importance of basic and applied research in total R&D activities, the product or process orientation of innovation efforts, and the extent to which firms enter into collaborative R&D with other institutions. As the propensity to enter into collaborative R&D increases, there is a stronger need for patent protection.

jurisdictions." The argument is also echoed by Gallini (2002), Sanyal and Jaffe (2006) and Bessen and Meurer (2008) who suggest that the increase patenting in the US can partly be attributed to lower examination standards at the USPTO. Low fees may as well have helped to push the trend upward: if the patenting process becomes cheaper, one would logically expect a higher demand for patents. Recent contributions have underlined the role of fees in shaping the demand for patent (see the survey performed by de Rassenfosse and van Pottelsberghe, 2010).

The consequences of the explosion in patent filings and the constant increase in their size (cf. Archontopoulos et al, 2007) have led to growing backlogs: an ever- increasing stock of pending applications. These backlogs are supposed to be detrimental to the economy because they are associated with a longer period of economic and legal uncertainty. In other words larger numbers of monopolistic rights hang over the shoulders of entrepreneurs, constituting potential threats to other businesses.

Beside this generalized upward trend in applications, there are important structural differences across countries. For instance, the USPTO workload fluctuates around 440,000 applications a year since 2006, more than twice as much as at the EPO. Japan seems to be stabilising around 400,000 applications per year, but these applications are much smaller than in the USA. In this respect one might logically wonder to what extent backlogs differ across patent offices?
Three measures of backlogs are put forward and discussed in van Pottelsberghe (2009) in order to gauge their relative degree of urgency at the EPO, USPTO and JPO. The indicators include the number of pending applications (for which examination is requested), the number of pending claims (because patents are much smaller in Japan than at the USPTO for instance), and the number of men-month required to digest the whole stock of pending applications. The three measures show that Europe's backlog is at the level of the US backlog in the mid-90s, a period during which there was no such problem in the US. Japan is systematically in an intermediate position.

A fourth indicator can be used as well to approximate the depth of the backlog issue: the average pendency or examination duration in each office. Increased pendency is actually the main argument raised by patent offices to underline the negative effect of backlogs. The trends depicted in Mejer and van Pottelsberghe (2010) have actually different trajectories: the average pendency has substantially increased at the USPTO over the past nine years (from 25 months in 2000 to 35 months in 2009; it has slightly increased at the JPO (32 months in 2008); and is actually decreasing at the EPO, although being substantially higher than elsewhere (from 51 months in 2001 to 43 months in 2008). In a nutshell, the main worrying effect of backlogs, longer duration, occurs essentially in the USA.[6]

[6] That the pendency is much higher in Europe is somewhat endogenous. It reflects different processes (applicants have six months to reply to a written communication by the examiner) and voluntary drafting styles that aim at delaying the grant date. This will is motivated by the sharp increase in patent costs that occur once the patent is granted by the EPO (cf. van Pottelsberghe (2009) or van Pottelsberghe and Mejer (2010)).

It is a matter of fact that the backlog issue is getting more intense over time in most patent offices. This trend is probably essentially caused by the globalisation phenomenon described above. The side effect of this trend is that it is associated with a drop in the average economic value of the filed applications. This is for instance witnessed by indicators based on geographical scope of protection and duration of renewals in Europe (see for instance van Pottelsberghe and van Zeebroeck (2008) or van Zeebroeck (2010)). But the trend should not hide the fundamental structural differences observed across patent offices. The backlog is essentially a problem in the USA, it is less an issue in Japanese, and is definitely much less worrying in Europe.

The present paper essentially focuses on the structural differences between large patent offices. Identifying the roots of these international differences (from a large backlog at the USPTO to a small one at the EPO) could help finding potential solutions. The paper aims at providing empirical evidence to the idea that the drastic backlog disparity between the EPO and the USPTO may be due to quality and cost differences. In the US, a low quality of the selection process put in place by the patent office and inexpensive patents would have led to a much higher propensity to file patents, which in turn could reduce further the quality of the examination process. This vicious cycle was underlined by Jaffe and Lerner (2004) for the US and by Guellec and van Pottelsberghe (2007) for Europe. It is theoretically illustrated by Caillaud and Duchêne (2009): if more low quality patents are filed, less resource can be devoted to examine them and it therefore becomes easier to have a patent granted. Yet, formally assessing the quality of patent systems has only been partially tackled in the economic literature.

3. A definition gap in the literature

- ***When stronger means weaker***

Scholars who have analyzed the effectiveness of patent systems generally focus on one or two facets of the system: patentable subject matters, duration, inventive step (or its scope), geographical scope, or a combination of these. In most scientific contributions scholars investigate the economic consequences of these four broad features. Four types of economic impact are generally considered: 1) does the patent system lead to more invention?; 2) does it stimulate more innovations?; 3) does it encourage more disclosure of new knowledge?; or 4) does it facilitate technology transfer and the creation of markets for technology (see e.g., Mazzoleni and Nelson (1998); Gallini (2002) Encaoua et al. (2006) or Guellec (2007)). In what follows some key contributions to this literature are briefly summarized. Most of these scholars implicitly or explicitly rely on a notion of 'strength' of patent systems and analyse the degree to which it contributes to achieve the ultimate goal of stimulating innovation and diffusing new knowledge.

Early theoretical investigations on the role of patent systems originated with Barzel (1968), Nordhaus (1969), and Scherer (1972) who argued that stronger patent systems would induce more investment in research and development. Since these early theoretical investigations most

landmark papers have essentially focused on three major aspects of policy making: the optimal length, the optimal breadth (or the optimal combination of these two dimensions), and the optimal geographical coverage of protection. For instance, Gallini (1992) analyses the optimal length of a patent according to the cost of imitation. Klemperer (1990) examines the optimal scope of protection, whereas Gilbert and Shapiro (1990) identify the optimal mix between length and breadth of patents. Scotchmer (1991) and O'Donogue (1998) explore how patent scope may affect the speed of generation and diffusion of new knowledge in a context of cumulative innovation processes. A too strong patent protection could lead to socially inefficient monopoly pricing and might stifle second stage R&D. On the other hand, a small inventive step leads to "hold-up" problems, whereby a patent granted for a small increment would actually provide more power to the second inventor.[7] The optimal patent policy should therefore balance the research incentives between subsequent generations of inventors. Scherer (2002) shows that whether stronger (stronger being defined as a larger geographical scope or stronger enforcement mechanisms) stimulate further innovation depends on the degree of research competition in a given technological field. The more competition takes place in the research arena, the lower the expected impact of a stronger patent system.

The results of empirical studies generally lead to the conclusion that "*strong"* patent systems have at most an ambiguous relationship with the rate of innovation and the degree of information disclosure, but that they do facilitate technology transfer, sometimes at the cost of anticompetitive behaviour. In this literature, the "*stronger*" terminology is much less used to echo the degree of quality in the selection process (or its rigour), than to reflect its enforcement potential, or "leading breadth" (future inventions might infringe on the patented invention). A common practice seems to qualify a patent system as *strong* (or *stronger*) when more domains are patentable (i.e., business methods, software or therapeutic methods) as suggested by Gallini (2002), when the term of protection is lengthened (cf. Grossman and Lai, 2004), when the geographical scope is enlarged (see Scherer, 2002) or when patent holders receive more power in lawsuits.

The indexes of "patent rights" put forward by Ginarte and Park (1997) for 110 countries from 1960 to 1990, and by Lerner (2002) for 60 countries over 150 years crystallize this tendency of defining "strong" patent systems as those which are essentially "applicant friendly".[8] Amongst the main criterion taken into account by the authors are the number patentable subject matters (few restrictions is synonymous to 'stronger'), a longer duration, and enforcement mechanisms that favour patent holders (for Ginarte and Park the provisions for protection loss are considered as a 'weakness', while preliminary injunctions, contributory infringement and burden-of-proof reversal are considered as a 'strength'). Lerner also adds the total cost for full (17 to 20 years) patent protection and an indicator of discrimination against foreign patent-holders.

[7] See Chang (1995), Denicolò (2000) and Denicolò and Zanchettin (2002) for further theoretical analysis of optimal patent policies under cumulative innovation processes.

[8] Claessens and Laeven (2003, Journal of Finance) are amongst the many scholars who use Ginarte and Park's index to evaluate the impact of patent '*strength*' on economic activity.

Strong is probably the wrong qualifier for such policies, which should rather be called "*applicant friendly*" as more domains can be patentable for longer, in more countries and with a strengthened legal power. According to Gallini (2002), "*... the same policies that are perceived to have strengthened patent rights in certain ways also have weakened them*". [p. 147]. By weakening the author means that patents are nowadays granted more easily than in the past. But no or little evidence is available so far to validate this assumption. One of the few authors who explicitly consider patentability requirement is O'Donogue (1998). His theoretical model suggests that more stringent selection criterion would provide longer incumbency (because it takes longer to perform more ambitious innovative projects), and hence higher innovation incentives at the first place. Dewatripont and Legros (2008) investigate the effects of patent race under a standard-setting context and show that litigation threats contribute to reduce the propensity to file low quality applications, but at the same time hinder the production of strong patents. One solution to reduce this negative side effect would be to sharpens the filtering process. Farrell and Shapiro (2008) also underline the importance of filtering, as the authors find that determining patent validity prior to licensing is socially beneficial.

It would be tempting to formally assess the rigour of the selection process with the grant rates of patent offices (i.e., the share of patent applications that are issued after the examination process), but this indicator can be heavily biased and therefore cannot be used as such to assess the rigour of patent systems.

- ***Biased grant rates***

Assessing the rigour of patent systems on the basis of their grant rates can be misleading, for four main reasons: metrics; patent flooding; divisional and continuation in parts (CIPs); and heterogeneous examination pendency. To start with the metric issue, patent offices rarely publish real grant rates. For instance, the EPO publishes the share of patent granted for a given year in the total number of patent "actions" of the same year (ie, refusals, withdrawals and grant). This practice would provide a logical downward-biased approximation of the grant rate, especially in a period of fast growing patent applications, because it does not account for the number of patents pending (see Harhoff (2009) for a theoretical contribution). A cohort approach is definitely more appropriate (i.e., the share of patents granted in the total number of applications for a given year). Indeed, official grant rates at the EPO in 2007 and 2008 were of about 50%, whereas the cohort approach shown in Lazaridis and van Pottelsberghe (2007) suggests a grant rate at the EPO that fluctuated between 60% and 65% all along the nineties. Despite the strong increase in patent applications since the mid eighties, the authors show that the grant rate of the EPO has been astonishingly stable, fluctuating around 65 percent. This is somewhat worrying: if the permanent increase in the number of patents was associated with a drop in the average quality of these applications, a stable grant rate would mean that lower quality patents have been granted.

According to Quillen and Webster (2001) and Quillen et al. (2002) grant rates are further biased by the presence of divisional applications or CIPs. Indeed, a divisional or a CIP means that one

patent can give rise to one or several subsequent patent applications with more or less claims, and sharing the same date of first filing. Needless to say, from the applicant's viewpoint, the grant of only one of these patents could be synonymous to a 100% grant rate, despite a small observed grant rate at the patent office. When corrected for these sources of bias, the USPTO's grant rate fluctuates between 87% and 97%, making it the most 'applicant-friendly' patent office in the world. This corrected grant rate should be compared with the corrected grant rates of 67% and 64% for the EPO and the JPO (for the period 1995-1999), respectively. These figures would tend to show that the JPO and the EPO have adopted a higher level of rigor than the USPTO.

A third source of bias is related to patent flooding practices, whereby applicants file many similar patents at once. Under such circumstances, there is a high probability that the patents would be allocated to different examining unit, to examiners with heterogeneous skills and years of experience. The grant of only one patent out of 10 would be seen as a 100% grant rate by the applicant, despite the 10% 'official' grant rate.

A fourth source of bias is related to examination pendency. Stevnsborg and van Pottelsberghe (2007) provide an exhaustive list of tactics used by applicants at the EPO to delay the grant date. This date is synonymous to a significant jump in expenses (cf. van Pottelsberghe and Mejer (2010) for cost simulations and Lazaridis and van Pottelsberghe (2007) or van Zeebroeck (2007) for evidence on delayed examination). If a patent is pending for 15 years, the assignees might decide to drop it in the public domain, which does not preclude them to have used the patent for 15 years (or to have kept the option to use it).

In a nutshell, grant rate indicators are at most biased approximations of patent offices' rigour in their selection process of patent filings. In addition, there is no or very little information on type I and type II errors (i.e., patent mistakenly granted or patents mistakenly refused, respectively), which must happen to a certain extent. It is however highly probable that 'wrongly' granted patent are more frequent than patents mistakenly refused. This is not only witnessed by the grant rates that are higher than 60%, but as well by the very low shares of 'refused' patents (about 5% at the EPO), the rest being withdrawn by the applicants (cf. Lazaridis and van Pottelsberghe, 2007). The RIM vs NTP case is an interesting symbolic example of unfair 'forced' settlement regarding Blackberry phones. It involved 5 patents "*that should not have been granted at first hand*" according to the U.S. Patent and Trademark Office. It seems that five patents from the same owner being mistakenly granted does not belong to a 'random' process, but rather to more systematic sources of errors. As shown by van Pottelsberghe and Archontopoulos (2010), none of these patents went through the EPO process, and two were actually withdrawn in a short time frame, probably due to a first negative communication from the European examiner.

Litigation and opposition rates are also biased indicators. They occur only for a minority of patents and no information is available on private settlements (it can be cheaper to settle than to go to court, even for low quality patents).

- ***Theoretical concepts vs day-to-day practice***

There is a definition gap in the literature that focuses on the breadth or scope of patent systems. Even when authors converge on what these abstract concepts mean, they rarely fits a day-to-day practice that is easy to implement, especially when compared to fees or length. For instance, Gilbert and Shapiro (1990) define breadth as the ability of the patentee to raise price. For Klemperer (1990) a larger breadth corresponds to "*a larger region of the product space*" that is included in the patent grant. Many other examples could be listed. Whereas they undoubtedly contribute to a better theoretical understanding of how patent systems work, the "breadth" or "scope" concepts are not easy to crystallize for examiners.

Gallini (2002)'s idea that patentability standards have fallen is driven by one main observation: there are more (new) patentable subject matters which have lead to a sharp increase in patent filings "*... for which the US patent office has limited expertise or access to prior art. .../... most notably in the area of business methods*"[p. 148]. If a drop in patentability standard is observed over time for a given patent office, due to policy changes regarding patentable subject matters and to the sharp rise in patent applications, one might legitimately wonder whether international differences occur in patentability standards, or in the way they are fulfilled. If patentability standard are the legal conditions under which a patent should be granted, an examination failure by the patent office would be a failure to comply with these standards.

Few authors have investigated the operational routines put in place by patent offices to comply with patentability standards, and when they do they tend to focus on a specific dimension of a multifaceted selection process. For instance, Scotchmer and Green (1990) suggest that novelty requirement and ownership rules ("*first-to-file*" vs "*first-to-invent*") are strongly interrelated concepts which affect the speed of innovation. Yamauchi and Nagaoka (2009) measure the impact of shortening the period allowed for requesting an examination at the Japan Patent office (JPO). The authors find that the primary impact of faster request for examination is to increase the workload of examiners with lower quality patents. The consequences of the grace period in the United States are scrutinized by Franzoni and Scellato (2010). The role of fees has been analysed in several respects over the past 10 years, for both pre-grant fees and post-grant renewal fees (see the recent survey by de Rassenfosse and van Pottelsberghe, 2010). Organisational and human factors have been investigated. Cockburn et al. (2002) examine the role of USPTO examiners characteristics (age, experience, etc) on the resistance of patent to validity challenges on court. Friebel et al. (2006) and Langinier and Marcoul (2009) consider the organisational practices and incentive mechanisms adopted by patent offices to gauge examiners' productivity. Lemley (2001) investigates the USPTO resources put in place to examine patents. The author argues that a patent office should not devote too much resource to secure a high quality examination, because there are too many patents with no economic value. As patent litigations mainly occur with high value patents, the court should be the 'right' place to gauge patentability conditions properly. Pre-grant opposition processes as opposed to litigations is precisely the field of investigation of Graham and Harhoff (2006) and Graham et al. (2002), who explore how a pre-grant opposition process would improve the US patent system. In a similar vein, Shapiro (2007)

assesses how reforms related to the U.S. patent litigation system (including the procedures by which patents are re-examined and damage assessment practices) could improve the effectiveness of patent system in fairly rewarding innovators.

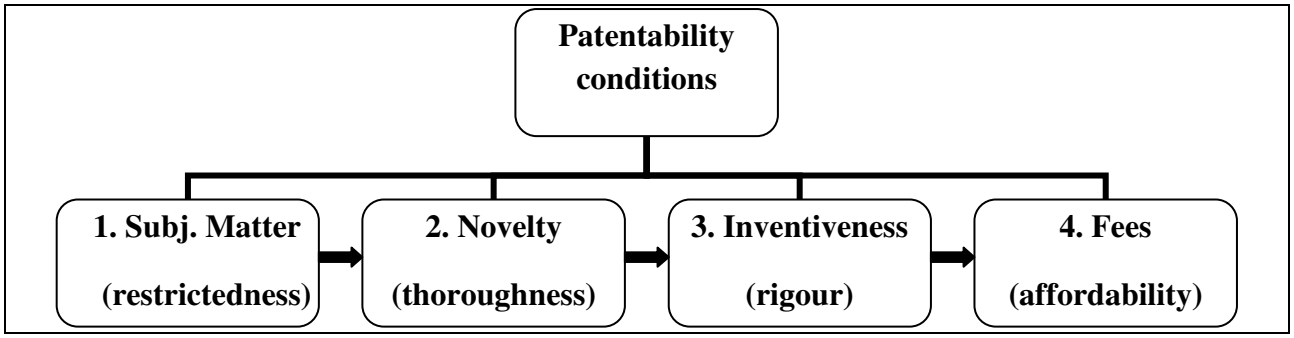
These theoretical and empirical contributions are part of a wide research field that focuses on the effectiveness of patent systems. Since they are 'focused', their implications are contextual and often fail to integrate complementarities with other features of the system. Scholars have as a matter of fact rarely or never investigated the whole processes put in place to check the patentability criteria in a systemic or comprehensive approach. In addition, most contributions explore only one patent office.

The targeted contribution to the literature of the present paper is precisely to provide a more systemic analytical approach, and apply it to three patent offices. Quality in patent systems, defined as the rigour of the examination process (or its ability to comply with the patentability conditions) and its transparency, can be assessed through the analysis of a two-layers framework composed of legal patentability standards and their operational design.

4. Quality analysis: a 2-layer framework

Comparing the level of quality in different patent systems is challenging. As explained in the previous section, selection rates (e.g., grant rates or litigation rates) are affected by systemic differences and a strong heterogeneity in the propensity to rely on the patent system across countries (see de Rassenfosse and van Pottelsberghe, 2009). This paper explores the quality issue from a different angle. Quality is defined as the extent to which patent systems comply with their own patentability conditions in a transparent way. It is therefore possible to gauge quality through a two-layer framework: the first layer would be composed of the legal standards that describe the patentability conditions of a national patent system. The second layer is characterized by the operational design put in place to meet these legal standards.

Figure 2. First layer: legal standards for patentability



The first layer reflects the broad dimensions of patent policymaking. Four interdependent legal standards shape the main conditions required to get a patent granted (cf. Figure 2): patentable subject matters, the identification of prior art (novelty condition), the examination process (inventiveness condition), and the fees to be paid (if fees are not paid no patent is delivered). A 'classical' legal standard could have been added, namely the maximum duration of a patent. It is voluntarily kept out of the analysis because it is rather homogenous across the US, Japan or Europe; and its implementation is clear-cut (i.e., number of years). In addition, the length is not really a patentability 'conditions', but a time limit in case of a grant.

The four legal standards that compose the first layers constitute the foundation of all patent systems, and some heterogeneity can be observed across countries. If fees and patentable subject matters are rather easy to identify and measure (see Ginarte and Park (1997) and Lerner (2002)), two 'key' legal standards, novelty and inventiveness, are less easy to compare across patent offices. Indeed, these two legal standards might be similarly codified in several patent offices, but their implementation, or the extent to which they are fulfilled, might drastically vary. We put forward that the degree to which a legal standard is satisfied depends on the "*operational design*" put in place by the patent office. Strong divergence in operational designs could lead to different degrees of quality (or rigor) in complying with patentability conditions. Table 1 lists the four main legal standards (LS), and describes the operational designs' (OD) main components for the novelty and inventiveness conditions. It briefly explains why each of these components might eventually affect quality and transparency in patent systems. As some components are more important than others in securing a thorough selection process and visibility, their relevance level on a 1 to 3 scale is indicated in the first column, 1 being of a low relevance and 3 a high relevance. For instance, the grace period concept (relevance 1) is less important than the opposition process (relevance 3), which allows third parties bring new prior art evidence.

The two-layers analytical structure presented in Table 1 has two main implications for the investigation of the degree of rigour (or quality) of the patent selection process. First, one should consider the four main legal standards as a whole, as they clearly interact with each other and form a coherent system. For instance, the quality of the search for prior art (the novelty legal standard, LS2) can be considered as one component of the inventiveness legal standard (LS3)'s operational design, because the quality of the search report will de facto influence the quality of the examination. In a similar vein, high fees would generate higher budgets (the elasticity of demand for patents with respect to fees is negative but much smaller than one) to secure high quality search and examination services. Second, the degree to which legal standards are achieved depends on the components of their operational design, especially for the novelty and inventiveness conditions.

Table 1. Quality in patent systems: legal standards (LS) and their operational design (OD)

System design	Why would it matter for quality?
(LS1) Patentable subject matters	**Some fields are less appropriate for patent protection, especially when alternative protection mechanisms exist, like copyrights (eg, software as such), plant variety protection or trademarks. Other fields are not patentable for ethical or security reasons (eg, human genome, weapons).**
(LS2) Novelty condition	**Novelty is in most systems the first condition to grant a patent. It must be assessed with respect to the state of the art (published material or public disclosure at conferences prior to the filing date). Novelty concerns both the description of a patent and its claims. The extent to which the novelty condition is properly assessed can be gauged through nine components of its operational design.**
- OD2.1. Subject matters - *Relevance level: 2*	If the prior art is not codified or cannot be easily identified or is part of common tacit knowledge; the novelty condition cannot be assessed properly. This is typically the case with several subject matters, like software, business methods, or traditional knowledge.
- OD2.2. Ownership - *Relevance level: 1*	The ownership of a patented invention can be allocate under a "*first-to-invent*" principle or a "*first-to-file*" principle. The former aims at being fair under a 'natural rights' umbrella, whereas the latter aims at stimulating the inventor to apply for a patent as soon as the invention pops up. The chosen system may affect quality, as the "first-to-invent" rule not only discourages disclosure but allows the first inventor to keep a claim on the market. In addition, litigations must start with the identification of the person who was 'really' the first inventor of the new product or process.
- OD2.3. Identification - *Relevance level: 2*	Relevant prior art should be listed (not more than that, not less) to properly delineate the scope of protection being sought. Who is primarily in charge of identifying prior art might affect the quality of the search report. If it is the applicant, one might expect loads of strategic listings, to a much larger extent than if it is the examiner.
- OD2.4. Search report - *Relevance level: 1*	Producing and publishing a search report makes the information public and allows: 1) the applicant to have a first assessment of the patentability of the invention (related to the novelty condition); 2) third parties to identify the filed invention in a transparent way.
- OD2.5. Language(s) - *Relevance level: 2*	The ability to read and understand several languages *de facto* enlarges the stock of codified knowledge an examiner has access to. Therefore, the likelihood of retrieving additional relevant documents increases and provides a better basis for the forthcoming examination.
- OD2.6. Opposition pr.	Thanks to the possibility to file an opposition, third parties can

- *Relevance level: 3*	submit new un-identified published material and documents to challenge the patentability of the invention; at a much lower cost than in the frame of litigation. Post grant oppositions frequently lead to revocation or amendment of the granted patent.
- OD2.7. Grace period - *Relevance level: 1*	Allows applicants to file a patent up to x months after a scientific publication of the invention. This high 'flexibility' could generate complex litigations, as scientific publication formats strongly diverge from a patent format, and as authors/inventors may vary. For instance, the fabrication mode and the patent-related prior art is rarely included in scientific publications. In systems relying on a strong novelty condition the grace period brings nuisance as claims wording might substantial diverge from the wording of a scientific paper.
- OD2.8. Controlled adaptability - *Relevance level: 3*	Applicants frequently want to adapt their patent, by modifying or enlarging the scope of protection (modifying claims or adding claims). This can be done either by adapting the patent or by filing new patents with the same priority date than the original application (i.e., Continuation in parts (CIPs) and Divisional applications). These routines are increasingly used to delay the examination process and adapt the patented invention to existing technologies; they increase the degree of uncertainty in the system. If patent claims can be adapted and strongly modified the relevant prior art might change and the search report could become less relevant.
- OD2.9. Hidden patents - *Relevance level: 2*	If the submitted patent can be hidden from third parties for a long period there is more uncertainty on the market and it precludes other patent offices to identify the patent as part of the prior art.
(LS3) Inventiveness	**Novelty as such is not enough to grant a patent, the invention should be significantly novel, or improve significantly as compared to the state of the art, so that it maintains market competition, reduces uncertainty and ensures sufficient protection to the inventors (Guellec, 2007, p. 134). The extent to which the inventiveness condition is properly assessed can be gauged through seven components of its operational design.**
- OD3.1. Novelty - *Relevance level: 3*	If the novelty condition is not properly assessed, the quality of the examination might be undermined. The more comprehensive and relevant the search report, the better the basis for the evaluation of inventiveness.
- OD3.2. Request exam. - *Relevance level: 2*	Whether or not the applicant has to request examination after a few years from the application date do affect the workload of examiners and the quality of pending patents.
- OD3.3. Definition - *Relevance level: 1*	The legal standard might be more or less stringent, hence influencing the required degree of inventiveness to grant a patent.
- OD3.4. Incentives[a] - *Relevance level: 2*	Motivational aspects, such as social recognition, remuneration, working environment, good management and fair evaluation processes play an important role, not only to ensure a serious

	work, but as well to keep experienced examiners in-house. Weak incentives might ultimately increase the turnover of employees.
- OD3.5. Examination skills[a] - *Relevance level: 3*	The education, experience and training of examiners obviously influence an examiner's ability to perform its task. Scientific and legal skills are required to carry out an examination. An examiner skill is also affected by her degree of interaction with other examiners.
- OD3.6. Low workload[a] - *Relevance level: 3*	If subject to a too high workload and insufficient resources to perform searches and examinations, quality might be affected. A high workload per examiner might lead to a faster work, and hence a less thorough examination.
- OD3.7. Opposition pr. - *Relevance level: 2*	The opposition process allows third parties to intervene and put forward potentially relevant arguments against patentability.
(LS4) Fees	**Fees affect the patenting propensity (see de Rassenfosse and van Pottelsberghe (2010) for a survey). High pre-grant fees would reduce the propensity to file applications of dubious quality. But it might as well reduce the accessibility for young innovative firms. High fees would also contribute to the financial sustainability of the office, especially if a high quality examination is correlated with high fees. For post-grant fees, High renewal fees induce a higher drop-out rate of patents in the public domain, and contribute to the financial sustainability of the patent office.**

a. Indicates transversal components which might affect the operational designs of two legal standards (novelty condition and inventiveness).

5. International comparison

This section aims at performing a systematic comparison of the legal standards and their operational design across three major patent offices, namely the USPTO, the JPO and the EPO. As the purpose of the paper is to assess relative degrees of quality, the three patent offices are to be ranked for each component of their legal standards' operational design. The rank goes from 1 to 3, from a low to a high level of rigour or transparency. Different scores are used when the component of an office's operational design has an obvious effect on the selection process (e.g., better identification of prior art or a more rigorous approach in the examination process) and on the transparency of the system (e.g., effective diffusion of information, easiness to identify the patent for third parties), when compared to another office.

- **LS1. Patentable subject matters**

Policies regarding patentable subject matter partly explain the difference in the number of patent applications between countries. In the US, the very few restrictions on patentable subject matters

would logically lead to more applications. This is striking for software, business methods, mathematical formulae, scientific discoveries or gene-related patents, amongst many other technological or scientific domains with lax patentability restrictions.

According to Gallini (2002) the policy changes in the US started in the early 80s, with the decisions *Diamond v. Chakrabarty* (1980) and *Diamond v. Diehr* (1981), where the Supreme Court extended patentability to genetically engineered bacteria and software, respectively[9]. In the late 90s the patentability of business methods and financial service products were confirmed following the Court decision in *State Street Bank and Trust v. Signature Financial Group*. These decisions paved the way to the patentability of Amazon.com's one-click Internet ordering process and other online auction or booking methods. As of April 2010, the US government might pass a new law that would restrict the patentability of software and business methods, especially following the *Bilski decision* by the US Supreme Court in October 2008, which restricts the patentability of business methods.[10] Whatever the final outcome related to this specific case, the US system, where "*everything under the sun can be patented*" is known to be much less restrictive in terms of patentable subject matter.[11] The "only" fields that are not patentable are those related to abstract ideas, laws of nature, natural phenomena and a human being. Databases as such, including gene expression profiles are not patentable.

Europe is much more restrictive and forbids the patentability of many subject matters. The European Patent Convention (EPC) defines what a patentable invention is and what fields do not correspond to that definition, like discoveries, scientific theories, mathematical methods, aesthetic creations, methods for performing mental acts, doing business, presentation of information. The exceptions to patentability include inventions that are contrary to "ordre public" or morality, plant or animal varieties or biological processes for production of plants or animals,

[9] Genetic engineer A. Chakrabarty (General Electric), had developed a bacterium capable of breaking down crude oil, for the treatment of oil spills. He requested a patent at the USPTO but was turned down by an examiner, because the law prescribed that living things were not patentable. The United States Court of Customs and Patent Appeals eventually overturned the case, writing that "*the fact that micro-organisms are alive is without legal significance for purposes of the patent law*." Sidney A. Diamond, Commissioner of Patents and Trademarks, appealed to the Supreme Court, which in June 1980 ruled that a live, human-made micro-organism is patentable subject matter under [Title 35 U.S.C.] 101. Respondent's micro-organism constitutes a "*manufacture*" or "*composition of matter*" within that statute.

[10] Bilski, (Fed. Cir. 2008), is a decision of the United States Court of Appeals for the Federal Circuit (CAFC) on the patenting of method claims, particularly business methods. The court affirmed the rejection of the patent claims involving a *"method of hedging risks in commodities trading"*.

[11] In the US, the main article related to patentable subject matter is Article 35 U.S.C. 101 "Inventions patentable". Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent thereof, subject to the conditions and requirements of this title. The Office requires that the claimed invention must produce a "useful, concrete and tangible result." The purpose of this requirement is to limit patent protection to inventions that possess a certain level of "real world" value, as opposed to subject matter that represents nothing more than an idea or concept, or is simply a starting point for future investigation or research. Subject matter found outside of, or exceptions to, the statutory categories of invention listed within 35 U.S.C. 101 include abstract ideas, laws of nature, natural phenomena and the claimed invention that encompasses a human being.

and methods for treatment of the human or animal body by surgery or therapy and diagnostic methods practiced on the human or animal body.[12] Japan is in a somewhat intermediate position, but is closer to Europe. The transgenic mouse is patentable but business methods, software as such and mathematical formulae are not eligible to patent protection, like in Europe.

Subject matters as such cannot be taken as indicator of quality or rigour in patent systems. The only certainty is that smaller number of restrictions on patentable subject matter would automatically lead to more patent filings. However, some subject matters might be characterized by unclear or difficult to identify state of the art, which would therefore affect the quality of the search report.

- **LS2. The novelty condition**

If the content of a patent application has been published (or presented at a conference) prior to the filing date (often called the priority date), the 'novelty' condition is not met and the patent should not be granted. This is theoretically straightforward and should normally be applied quite stringently. However, identifying the relevant state of the art is not always straightforward. The thoroughness of a patent office ability to comply with this legal standard can be gauged through nine interrelated components of its operational design.

OD2.1. Subject matters: the legal standard on patentable subject matters affects the quality of the search for prior art, especially when the subject matter includes non-codified but well known processes. For instance, software and business methods are technological areas for which it is much more difficult to identify the relevant prior art properly, because of a lack of codification of previous 'inventions', or because of inventions being hidden in a source code. The USPTO therefore is less able secure a stringent list of prior art for the technological areas that are related to software, business methods and any subject matter with an incomplete codification of its state

[12] In Europe, two important EPC articles related to patentable subject matter are Articles 52 and 53. Article 52 "Patentable inventions" includes the following points: (1) European patents shall be granted for any inventions, in all fields of technology, provided that they are new, involve an inventive step and are susceptible of industrial application. (2) The following in particular shall not be regarded as inventions within the meaning of paragraph 1: (a) discoveries, scientific theories and mathematical methods; (b) aesthetic creations; (c) schemes, rules and methods for performing mental acts, playing games or doing business, and programs for computers; (d) presentations of information. (3) Paragraph 2 shall exclude the patentability of the subject-matter or activities referred to therein only to the extent to which a European patent application or European patent relates to such subject-matter or activities as such. Article 53 "Exceptions to patentability" stipulates that European patents shall not be granted in respect of: (a) inventions the commercial exploitation of which would be contrary to "*ordre public*" or morality; such exploitation shall not be deemed to be so contrary merely because it is prohibited by law or regulation in some or all of the Contracting States; (b) plant or animal varieties or essentially biological processes for the production of plants or animals; this provision shall not apply to microbiological processes or the products thereof; (c) methods for treatment of the human or animal body by surgery or therapy and diagnostic methods practiced on the human or animal body; this provision shall not apply to products, in particular substances or compositions, for use in any of these methods. Rule 27, on patentable biotechnological inventions include the following: (a) biological material isolated from its natural environment; (b) plants or animal if the technical feasibility of the invention is not confined to a particular plant or animal; (c) microbiological process other than a plant or animal variety.

of the art. Because of these 'unclear' subject matter, the USPTO would have a lower rank (1) than the JPO and the EPO (2) in terms of rigour (Table 3 lists the quality rank for all components of the legal standards' operational design).

OD2.2. Ownership: The USPTO is the only office, jointly with one or two others in the world, to give the ownership of a patented invention according to the "*first-to-invent"* principle. In the rest of the world, including Europe and Japan, the "*first-to-file"* principle prevails. This peculiarity affects quality in two ways. First, the "*first-to-file"* principle has the advantage of stimulating an early disclosure of the invention, hence making it accessible to the public faster. With the *"first-to-invent"* rule an inventor does not need to patent in order to keep a claim on the market related to its invention.[13] Second, in case of litigation a patent dispute will often start with the right of ownership issue, whereby the "true" first inventor must be identified. Scotchmer and Green, (1990) argue that in case of a technological race the *"first-to-file"* principle might create excessive incentives for firms to stay in the race. In this respect, and provided their theoretical model is supported by empirical evidence, the *"first-to-invent"* rule could be more effective in reducing duplicative research efforts, but this aspect is not related the quality of the patent system.

OD2.3. Identification of prior art: Who is in charge of identifying the prior art will *de facto* influence the quality of the search report (comprehensiveness and relevance), and hence the degree to which the novelty condition is met. The three offices have adopted different strategies for the implementation of the search report, and the JPO and the USPTO tend to converge. To start with, in the USA and Japan a comprehensive list of prior art must legally be submitted by the applicant. In Europe it is the duty of the examiner to establish the relevant search report, which does not preclude the applicant to include a list of prior references in the submitted document. In Japan the search report has been outsourced for many years to the private sector.

In the USA the applicant is legally bound to disclose the state of the art related to its invention, which might lead to two potential biases. First is the practice that consists in overloading the reference section, so that the examiner might not be able to easily identify the most appropriate piece of prior art against which the novelty and inventiveness conditions must be checked. Second, some key technical references might not be listed by the applicant, and hence might not be taken into account by the examiner if he does not identify them. The USPTO has been investigating the contracting out of searches since the early 2000s. The Office has started by means of a proof of concept a pilot conducted on the search reports prepared for international applications under the PCT. According to Kezenske (2003) contractors must demonstrate technical and legal competence, that there is no conflict of interest between these and other searches they carry out, and that they will maintain strict confidentiality.

[13] An example (taken from Scotchmer and Green, 1990) is provided by Yoshikawa (1987), who describes a patent dispute between the Japanese firm Sankyo and the US firm Merck. The dispute on an anticholesterol drug was settled differently in Japan and the US because of these different ownership rules. Sankyo had the first patents on the two markets, but the patent was issued to Merck in the U.S. because the firm could document prior invention.

Japan has outsourced for many years the search reports to independent organisations in the private sector. About 225,000 search reports were outsourced in 2008, of which 80% (or 180,000) were of "*dialogue-type*" outsourcing. The expansion of outsourcing of prior art document searches is mainly due to the commencement of operation of new registered search organizations, the recruitment of searchers in the registered search organizations and increase in their processing capacity. In 2009, about 1840 employees were working for height search organizations, of which about 88% were employees of the Industrial Property Cooperation Centre, and include a substantial number of former examiners.[14]

The EPO has adopted a strategy which is opposed to any type of 'outsourcing' to the private sector. For the office it is particularly important to have the search report performed by the examiner.[15] The implicit advantage of this practice is to improve examiners' broad knowledge of the relevant prior art and hence sharpens their ability to gauge the inventive step.

In a nutshell, the USPTO and the JPO are subject to potential drafting behaviours that consist in not listing relevant prior art, or hiding it in a long list of irrelevant references. The JPO relies extensively on outsourcing practices, and the USPTO is planning to evolve in a similar direction. Beside the many sources of potential information asymmetries (competencies, conflict of interests and confidentiality), such practice does not contribute to improve the examiners' own knowledge of the prior art (the examiner discovers a reference list provided by third parties and must assess the inventive step from it), which is implicit at the EPO. For these reasons (examiner-made search reports) the identification of relevant prior art might be more comprehensive at the EPO than at the USPTO or JPO.[16]

OD2.4. Intermediate search report: The fact that no search report is publicly available (especially for domestic applications) witnesses a lack of transparency on the part of the USPTO and JPO especially when compared with the EPO. At the EPO, the search report includes all the relevant prior art and is published along with the patent application 18 months after the priority date. Any patent application following the PCT route (whatever the selected search authority)

[14] According to the JPO 2009 annual report, "dialogue-type outsourcing" means an outsourcing method in which the patent examiner receives the report of the search result from the searcher together with the oral presentation of the searcher and on the basis of this report, when necessary, the patent examiner conducts further a supplementary search. The officially registered search organizations include the Industrial Property Cooperation Center (all classes with 1,621 employees); Techno Search, Inc. (several classes, 94 employees); Japan Association for International Chemical Information (organic compound, 22); Technology Transfer Service Corp. (amusement, 32); Advanced Intellectual Property Research Institute Co., Ltd. (opto device, 21); Patent Online Search Corp. (amusement, 24); Pasona Group Inc. (automatic control, 14); Protec Ltd. (semiconductor device, 12).

[15] In the eighties and early nineties the search report was done by the employees based in the "The Hague" branch of the EPO, and the examination was performed in the Munich branch. The late nineties saw the implementation of the BEST programme (Bringing Examiners and Searchers Together), which is believed to have improved the quality and speed of the whole examination process at the EPO.

[16] The fact that the merger of existing prior art documents does not preclude to satisfy the novelty condition is another indicator of the 'softness' of the US identification of prior art. According to Barton (2000) prior publications in the US system would not bar issuance unless all features of the invention have been disclosed in a single prior publication, which is not systematically the case in Europe.

automatically leads to the publication of the patent and its international search report, for the three offices. The lack of search reports for domestic applications in the USA and Japan reduces the ability of other applicants (or third parties, like entrepreneurs) to properly assess the patentability of their inventions, and therefore worsens the self-selection process. The EPO systematically add to its search reports a non-binding opinion on patentability, which provides precious information to applicants, and hence increases further the drop-out rate.

OD2.5. Languages of prior art(s): The novelty condition is essentially based on the formal identification of relevant prior art. This prior art is logically assessed within the scope of all published documents in the language(s) spoken by the examiners. For the USA this is essentially scientific and technical work published in English, and for Japan it is essentially in Japanese and probably as well in English. A great advantage of the EPO in this respect is that most examiners are fluent in the three official languages (German, French and English). Therefore, having access to a wider knowledge base than US or Japanese examiners, EPO examiners provide a more comprehensive identification of prior art.

OD2.6. Opposition process: With a post-grant opposition process, third parties may challenge the patentability of an invention by submitting additional prior art that would have not been identified by the examiners. The EPO has a low cost post-grant opposition system that allows any third party to challenge the patentability of a patent for a period of 9 month from the decision to grant. This intrinsic self-correction mechanism logically improves the identification of prior art and may lead to the revocation of the patent. There is no post-grant opposition process at USPTO or JPO.[17] In the US there are two features that may lead to the cancellation of a granted patent: interference proceedings and re-examination. The first feature is a priority contest between applicants/patentees seeking to protect the same invention and the second feature may be requested by third parties or by the patentee during the lifetime of a granted patent. Validity challenges are also possible in Japan and all European countries, but they take place in the frame of a regular litigation.

OD2.7. The grace period: This is a period during which the inventor is allowed to publish its invention, generally through scientific working papers or conferences, and to submit a patent application on the same content at the end of the period, without being barred for failure to respect the novelty condition. This flexibility is particularly welcomed by academic researchers, because the patenting process does not obstruct or delay their publication output. In general it is considered to be 'applicant-friendly'; whereas a system without a grace period protects more the interests of third parties. Grace periods allow the authors of the published material to 'reserve' for several months the invention without the inconvenience or cost of filing a patent. It also delays the date at which the invention will fall in the public domain (cf. Franzoni and Scellato, 2010). For third parties the grace period is synonymous to a longer period of uncertainty. In addition, as a scientific article or a conference presentation is drastically different in its format and structure

[17] Due to the 2003 revision of law, the system of opposition to the grant of a patent was integrated into the system of trial for invalidation of a patent, and can therefore be considered as a litigation proceeding.

than a patent, the grace period can be seen as a time span during which the applicant can substantially adapt its invention. In case of litigation, comparing a patent with a scientific paper might prove to be an intellectually acrobatic exercise. The US welcomes this 'grey zone' for one year, and Japan for 6 months. Europe has no grace period.

OD2.8. Controlled adaptability: Applicants logically try to obtain the largest scope of protection in order to maximise the strength of their patent in case of litigation. An additional motivation is that technology evolves, and patent owners try to have claims that fit better to the latest design of their invention. The EPO and the USPTO have drastically different approaches regarding the degree of flexibility related to the number and content of claims. The flexibility actually depends on the type of changes that are requested. Three types of change may be considered: adaptation of the claims and description for a given invention; strong adaptation including much more claims and subject matter through the filing of subsequent patents (continuation in parts, CIPs); and split of a large patent into one or several smaller patents (divisional applications). The first adaptive mechanism is slightly favoured at the EPO, whereas the last two are favoured at the USPTO.

At the EPO applicants may adapt their claims and description (change, withdraw or add claims) up to the grant, under the supervision of the examiner and provided the changes do not add new subject matter.[18] This flexibility has been reduced since April 2010, but will still be possible. In Japan it is possible to amend the patent (i.e., adding, modifying or withdrawing claims) until the first office action, which provides up to a bit more than 3 years from the application date to make modifications. At the USPTO such type of amendment is more difficult, claims cannot be redrafted and a maximum of two modifications are allowed, but it is easy to file subsequent patents, through the 'continuation' processes.

Continuation application (CAPs) and continuation in parts (CIPs) are subsequent applications linked to a priority (first) filing, which share the same 'priority date' (date of first filing). CIPs may add, change, or withdraw numerous claims to the original application. It is a process frequently used by applicants at the USPTO in order to maintain important claims under examination while enlarging the scope of protection. The possibility to add claims in several subsequent CIPs provides an incentive to file further applications and adapt the contour of the intellectual property to the evolution of the technology (whoever owns the technology). Companies increasingly use CIPs in the USA, as illustrated by Quillen and Webster (2001),

[18] The extent to which a patent application can be amended (be it for its description, claims or drawings) is governed by EPC rule 137 "Amendment of the European patent application", which is allowed (1) Before receiving the European search report, the applicant may not amend the description, claims or drawings of a European patent application unless otherwise provided. (2) After receipt of the European search report, the applicant may, of his own volition, amend the description, claims and drawings. (3) After receipt of the first communication from the Examining Division, the applicant may, of his own volition, amend once the description, claims and drawings, provided that the amendment is filed at the same time as the reply to the communication. No further amendment may be made without the consent of the Examining Division. (4) Amended claims may not relate to unsearched subject-matter which does not combine with the originally claimed invention or group of inventions to form a single general inventive concept.

Quillen et al. (2002) and Hedge et al. (2009). Such practice not only provides a substantial opportunity to adapt patents, but also artificially increases the number of patent applications at the USPTO. The evidence provided by Hedge et al. (2009) show that about 30% of all US corporate-assigned patents included at least one continuation. CIPs are not allowed in Japan and Europe.

The third type of flexibility, called divisional application, are patents with numerous claims that are split into one or several smaller patents, in order to ensure unity of the inventions, or in order to delay the grant date, or if the applicant wants to hide a few claims (amongst several hundred), or when the applicant does not know yet which claim could be useful. There are two side effects: delay in the grant date and longer uncertainty on the market. In Europe divisional applications are also allowed. However, abusive reliance on divisional applications has been limited since April 2010, with the decision by the EPC to allow only one divisional application per priority applications (up to now subsequent divisional applications of divisional applications were allowed, with the extreme case of having claims pending for nearly twenty years).[19] The US system allows for intensive use of CIPs and divisional applications.

To sum up, the US system is the most flexible with respect to the novelty condition, as it allows easy and numerous adaptations to the patent document, while keeping the same priority date. The EPO and JPO are much less flexible in this respect, and hence provide a higher degree of certainty and visibility to third parties. For small changes (under the scope of the invention described in the first patent), however, the EPO and the JPO are more flexible. They allow companies to adapt and fine tune their patent under the supervision of examiners. One consequence of these heterogeneous practices is that the examination pendency can barely be used to compare patent offices. At the EPO the amendment of a patent induces communication and validation with the examining division, which naturally increase pendency: if the applicant wants a change, some additional time is naturally needed. In the US the flexibility essentially takes place through the filing of a CIP. In other words, a strong change in the targeted scope of protection actually takes the time of examining two or more subsequent patents.

OD2.9. Hidden applications: The possibility to hide patents (or claims) introduces uncertainty in the system, especially for entrepreneurs who are active in the technological area covered by the hidden claims. In most countries patent applications are kept secret (unpublished) for 18 months from the date of first filing. The patent application is then automatically published, except in the USA. At the USPTO, only patent applications for international markets (under the PCT route) are automatically published after 18 months. Domestic applications targeting the US market alone can be kept secret during the whole examination process and be published only if and when they

[19] See the rule 36 of the EPC: an applicant has a maximum of 24 months from the examining division's first communication in respect of the earliest application on which the divisional is to be based. This earliest application has to be pending at the time the divisional application is filed, and it cannot introduce new subject matter that extends beyond the content of the earlier application (Art. 76(1) of the EPC). This new rule will substantially reduce the filing of divisional per patent application, limiting therefore the possibility to 'game' the system.

are granted.[20] This applicant-friendly specificity undermines the US patent system, as it encourages '*submarine*' strategies that consist in keeping a patent pending (and hence unpublished) until its grant, and then immediately enforcing it. In Europe (nearly) all applications are published 18 months after their priority date. It is possible to hide an application only if it is refused by an examiner (or withdrawn by the applicant) before the official publication date. In Japan all applications are published 18 months after the application date.

A second way to hide proprietary technology, even if the patent is published, is to file so-called "jumbo" applications, which include several hundred claims and pages. Finding the relevant claim, especially for the would-be entrepreneur who performs a freedom to operate analysis, is like finding a needle in a haystack. These applications generally lead to several subsequent divisional applications. Large applications have become more expensive more recently, with higher claim-based fees set up by the USPTO and EPO. And as explained in the previous subsection (see OD.2.8 Controlled adaptability), the use of divisional application is much more limited at the EPO than at the USPTO.

In a nutshell (cf. Table 3 for a summary of the qualitative comparison of the three offices according to legal standards and the components of their operational design), the nine components of the operational design related to the novelty condition, taken as a whole or individually, suggest that the US has a softer implementation of the novelty condition, whereas the EPO has a more rigorous approach, in terms of both identification of prior art and transparency. Japan is in an intermediate position, closer to the US for a few dimensions and closer to the European system for others. The softness of the USPTO is characterized by many patentable subject matters for which the state of the art is not properly codified, a first-to-invent system, the applicant's identification of prior art, the lack of search reports, a single working language, no opposition process, a long grace period, the easiness to substantially adapt claims and content during the examination process, and the possibility to hide applications.

- **LS3. Inventiveness**

The legal standard for the inventiveness condition in Europe is that the invention should be significantly different from the state of the art, or involve an "inventive step". In the USA the condition is somewhat similar at first sight; "non-obviousness" is required to grant a patent. The

[20] The public rule on "USPTO website states: "*Publication of patent applications is required by the American Inventors Protection Act of 1999 for most plant and utility patent applications filed on or after November 29, 2000. ..., an applicant may request that the application not be published, but only if the invention has not been and will not be the subject of an application filed in a foreign country that requires publication 18 months after filing (or earlier claimed priority date) or under the Patent Cooperation Treaty. ... As a result of publication, an applicant may assert provisional rights. These rights provide a patentee with the opportunity to obtain a reasonable royalty from a third party that infringes a published application claim provided .../... and a patent issues from the application with a substantially identical claim. Thus, damages for pre-patent grant infringement by another are now available*".

operational design put in place to test the inventiveness condition can be analyzed through seven components.

OD3.1. Novelty condition: According to the UK Trade Marks, Patents and Design Federation (TMPDF), a timely and high-quality search is central to the quality of the EPO examination capability[21]. Therefore, a low rigour in the identification of prior art, or a soft novelty condition, is a first element that might hamper the quality of the examination process. The previous subsection on the novelty legal standards provides evidence suggesting that the novelty condition is softer, or assessed with less rigour in the US than in Europe, Japan being in an intermediate position.

OD3.2. Request for examination: A filing at the USPTO automatically leads to a search and examination, whereas at the EPO and the JPO the applicant must make a specific request for examination (otherwise the patent falls into the public domain). At the EPO the applicant also benefits from a search report after 18 months, which provides preliminary clues on patentability and hence increases the drop-out rate (Lazaridis and van Pottelsberghe (2007) show that 20 to 30% of all withdrawals take place just after the search report, witnessing the usefulness of this 'request'). At the JPO a request for examination can be made up to 3 years after the filing date. Here the decision process of the applicant relies essentially on its self economic assessment of commercial value, because no search report is available. Prior to October 2001 this period was of seven years. Yamauchi and Nagaoka (2009) show that the shortening of the request for examination period has led to a sharp increase in the number of patents to be examined, an increase associated with a fall in average quality. The advantage of a 'request' system is that it reduces the share examinations that are performed for patents that will not be used. This self selection process contributes to reduce the number of pending applications. The weakness of the 'request' system is that it prolongs the period during which the unexamined applications may block other firms' activities. The period is shorter at the EPO than at the JPO but is associated with a non-binding opinion on the patentability of the invention, which improves further the self selection process (based on both the economic potentials and the technical opinion submitted by the examiner).

How would these three different processes affect quality of the examination process? The combination of an 18 months period with a search report and a non-binding opinion allows to reduce the number of examination requests while reducing uncertainty for third parties. In Japan, the examination request lag is longer (hence reduces further the number of requests for examination) but is only based on the potential market value of the invention and not on its potential patentability (no search report is available). The USPTO favours speed, but at the cost of more examinations to perform on patents with a lower average quality.

[21] '*A high quality search underpins everything, for without it, the rest of the examination process can be a waste of time. Moreover, reliably good early searches can lead applicants to abandon applications that would otherwise clog the system';* TMPDF (2008, p. 2).

OD3.3. Definition: At the USPTO the patentability condition that is assessed during the examination is the "non-obviousness" criterion, which is perceived to be more lax than the criterion used by the EPO or JPO, which consist in identifying an "inventive step". The two concepts are somewhat similar but the practices put in place to assess them differ. At the EPO the evaluation of the inventive step is based on the problem-solution approach and the "could-would" concept. In the US the concepts that prevail in courts are the "teaching-suggestion-motivation" (TSM) test and the "Graham" factors.

The EPO's inventive step is considered to be achieved if, when compared to the state of the art, the claimed invention is not obvious to a person 'skilled in the art' (European Patent Convention, EPC, Art. 56). The EPO has adopted since the early 80s the "problem/solution" approach (Guidelines Part C, chap. IV, section 9; and explained in Guellec, 2007), which requires establishing the objective technical problem to be solved (which corresponds to the difference between the invention and the closest prior art) and then considering whether the claimed invention (or 'solution' to the technical problem) would have been 'obvious' to the person skilled in the art. Such a 'person' is defined as an ordinary practitioner aware of what was common general knowledge at the date of invention.[22]

In the USA the critical inquiry is whether there is something in the prior art to suggest the obvious nature of the combination of previously known elements. This requirement is generally referred to as the "teaching-suggestion-motivation" (TSM) test. In order to prove obviousness, this test requires to show that some suggestion or motivation exists to combine known elements to form a claimed invention. The TSM test has been the subject of much criticism, as illustrated by the U.S. Supreme Court in KSR v. Teleflex (2006), which held that the true test of non-obviousness is the Graham analysis.[23]

Some scholars argue that in the US the non obviousness rule has been relaxed at least for particular subject matters (e.g., Gallini (2002), Jaffe (2000) and Barton (2000)). Comparing patent offices' inventiveness from the definition of '*inventive step*' or '*non-obviousness*' is far from being straightforward. It is worth mentioning that the rules in Europe (ie, the "problem-solution" approach and the "could-would" concept) were created by the EPO to ensure a homogeneous approach for examiners coming from different countries and examination culture. The TSM test and especially the "Graham factor" were created and used by Courts (Federal Circuit or the Supreme Court), which witnesses a more pronounced application of rules in the court room than in the patent office.

[22] The "could-would" concept consists in investigating whether the skilled person would have been prompted to modify the closest prior art in such a way as to arrive at something falling within the terms of the claims. In such a case the invention does not involve an inventive step and is therefore not granted.

[23] According to the "Graham factors", obviousness should be determined by looking at 1) the scope and content of the prior art; 2) the level of ordinary skill in the art; 3) the differences between the claimed invention and the prior art; and 4) objective evidence of non-obviousness. In addition, three factors might used to provide evidence of non-obviousness". They are 1) commercial success; 2) long-felt but unsolved needs; and 3) failure of others.

Important elements related to the patentability condition may however contribute to push the EPO upward on the quality ladder: the notion of clarity and support by the description (Art. 84 EPC), the notion of sufficiency of disclosure (Art. 83 EPC) and the notion of unity of invention (Art. 82 EPC). These provisions can be found in most patent systems, but it seems that the extent to which they are ignored or not varies across patent offices, and is probably related to the time allocated for a proper examination, as explained in the following components of the inventiveness' operational design.

In a nutshell, the arguments presented in this "*definition of inventiveness*" section are not sufficiently grounded to conclude that the USPTO has a substantially lower or higher degree of inventiveness than the EPO or JPO.

OD3.4. Incentives (wages and social recognition): The incentive to stay at the office and perform a high quality examination is related to employment conditions. USPTO examiners are civil servants, with wages that are not particularly competitive. The position is often used as a stepping stone to higher wage jobs in the private sector, which needs experts who know how to make a patent granted (NAPA, 2005, p.82). A direct consequence is the high turnover of employees at the USPTO, of about 33% (the average employee stays three years on average). In Japan the patent office is a branch of the Ministry of External Trade and Industry (METI) and its employees have a fairly high wage and social recognition, which translate into a very low turnover. The EPO also has a low turnover of its workforce (less than five percent) and very high wages, as examiners have the status of international civil servants, with many additional advantages (holidays, educational support for children...). The social recognition of EPO examiners is rather in an intermediate position. The EPO is located outside the policy making arenas (it is mainly based in Munich and in The Hague), and is independent from European institutions.

In addition to these structural differences in wages or social recognition, opposite incentive mechanisms have been put in place. The USPTO has more pronounced orientation towards "explicit" incentive mechanisms, whereby the quantity (and speed) of work performed by an examiner will partly determine its wage, whatever the quality of the examination.[24] The EPO and JPO rely more on an "implicit" incentive scheme based on peer review mechanisms (several dimensions of the day-to-day work matter, including training, social interaction, improvement of patent classification and help of colleagues). The literature on agency theory (cf. the survey by Friebel et al., 2006) underlines that explicit incentive mechanisms can be a powerful tool in case of information asymmetries between the management of an organization and its members. But they can lead to a behaviour that is detrimental to the goal of an organisation, especially when the work is complex and subject to uncertainty. For the patent examination process, explicit

[24] Regarding the USPTO, M. Lemley reports that *"There are strong structural and psychological pressures on examiners to issue patents rather than rejecting applications, no matter how weak the alleged invention seems."* Lemley (2001, foot note 5).

incentives exclusively based on quantity and speed would logically affect downward the quality of selection work.

OD3.5. Examination skills (education, experience and feedbacks): the very low turnover of employees (less than 5 percent) at the EPO and JPO is evidently correlated with a more pronounced experience of the average examiner, especially when compared to the USPTO, where each examiner would spend only three years on average before joining the business sector. An examiner at the EPO is recognised as fully operational after five years of training and experience. Since the examination process is complex, technical and legally binding, examiners with longer experience would obviously deliver a higher-quality service on average.[25] At the USPTO almost 80 percent of patent examiners had fewer than three years of examining experience in 2009, whereas the share of examiners with more than 10 years has fallen from 20% in 2004 to 7% in 2009. This drop is the result of both an aggressive recruitment of new examiners by the USPTO and a significant reduction in the number of experienced examiners (from about 750 five years ago to about 400 nowadays).[26]

The extent to which interactions take place between examiners is an aspect of the examination that implicitly affects an examiner's ability to assess the degree of inventiveness of a patent. The questionnaire survey presented in Friebel et al. (2006) shows that the work of examiners is perceived by them to be highly interdependent, whereby a poor quality work by one examiner increases the load of her colleagues. In this respect, the EPO has a well defined and unique practice that consists in having a Division taking the decision to grant a patent, which involves three colleagues in the examination process: the first examiner, the second examiner, and the chairman. This organisational routine constitutes a key quality check in the EPO process, and institutionalizes substantial interactions between examiners.[27] At the USPTO, the examination is more performed at the individual level. Cockburn et al. (2002) provide evidence of a strong heterogeneity across examiners in their examination process. The heterogeneity is related to their experience, tenure and other characteristics.

OD3.6. Workload and pendency: Various measures of workload per examiner are presented in Table 2 for the year 2008. The ratio of incoming applications per examiner is presented in columns [4] and [5]. Column [4] shows the total number of applications for which a search of prior art must be performed, 74 at the USPTO against 59 at the EPO. In Japan the 'search for

[25] This positive correlation between an examiner's experience and the quality of her work is further documented by the British Trade Mark, Patents & Design Federation: *'A number of our members have experienced poor quality search and examination, which some attribute to the work of new recruits who have had less training and supervision than used to be provided'* TMPDF (2008, p.3).

[26] Cf. http://www.patentlyo.com/patent/2010/02/patent-examiner-experience-levels.html.

[27] The first examiner analyses the application, writes communications to the applicant and analyses their replies and amendments, recommends grant or decides to recommend refusal. The second examiner checks recommendation to grant (votum) or refuse, checks form of final text of granted patent, agrees to grant or refusal or sends application back to the first examiner with comments. The chairman checks legal and technical reasoning of the first examiner's votum or refusal, carries out a detailed check of the text of the final application documents, agrees to grant or refusal or sends the application back to the first examiner with comments.

prior art' workload is less relevant, as it is outsourced. This higher workload for US examiners is exacerbated when examination duties are considered. Column [5] displays the number of patents for which a substantive examination must be performed. The two columns show a significantly higher workload in the US, especially for the substantive examination. The JPO seems to have a substantial workload, but this is due to the fact that patents in Japan are much smaller. This "claim-number" effect is taken into account in columns [6] and [7], which present the total number of claims filed per examiner (for search report) and claims under examination per examiner, respectively. For prior art search, an examiner at the USPTO must tackle more claims than at the EPO. For substantive examination the average examiner at the EPO receives about 540 claims per year, about three times less than the 1,776 claims per examiner in the USA and 1,403 claims per examiner in Japan.

Column [8] in Table 2 shows that the actual amount of work performed per examiner is also twice as high in the US as in Europe. The European examiner grants on average 15 patents per year, against 29 in the US and much more in Japan (but these are smaller patents). These figures suggest that both the incoming workload of examiners and their actual production are two to three times higher at the USPTO than at the EPO, the JPO being in an intermediate position.

Table 2. Rigour in patent production process, 2008

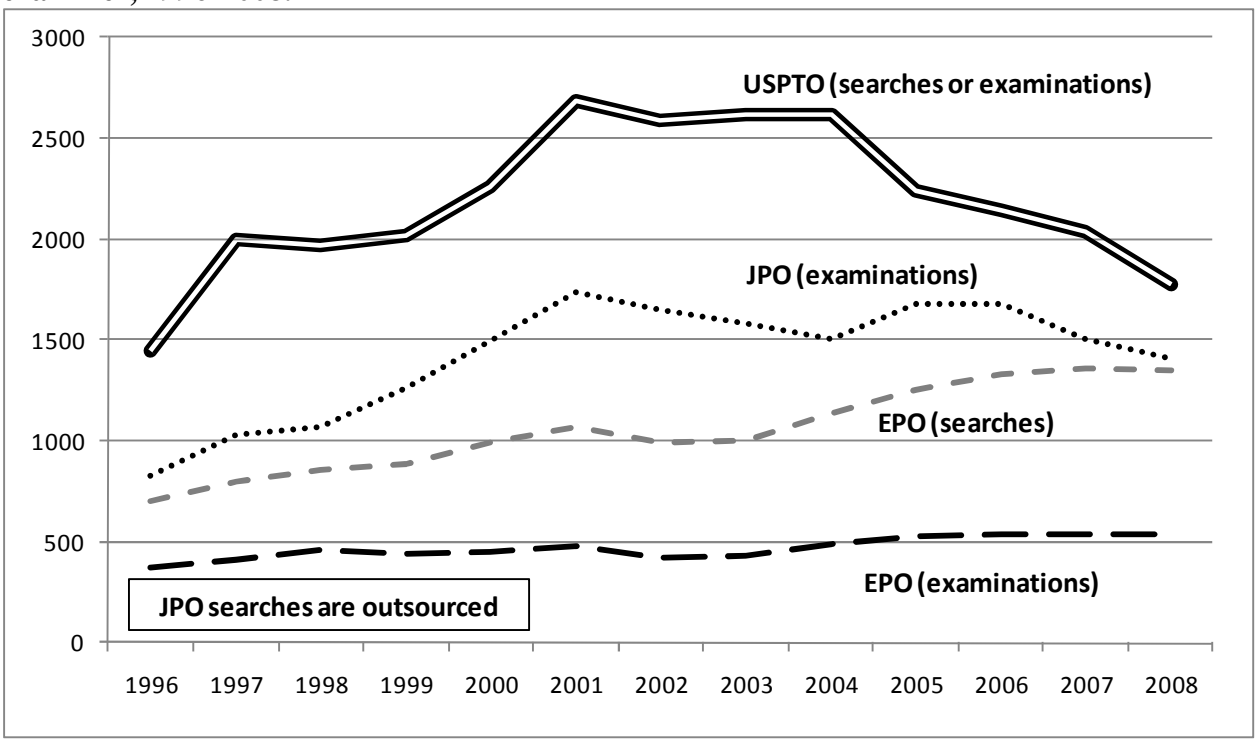
	Examin (EX) [1]	**Filings (IN)** [2]	**Grant (OUT)** [3]	**IN/EX (search) [2]/[1]= [4]**	**IN/EX (exam)** [5]	**INC/EX (search)** [6]	**INC/EX (exam)** [7]	**OUT/EX [3]/[1]= [8]**	**Pendency in months** [9]
USPTO	6,055	448,000	159,961	74	74	1,776	1,776	26.4	32
JPO (1)	1,680	391,002	154,699	n.r.	156	n.r.	1,403	92.0	(36)+32
EPO	3,868	226,813	59,819	59	36	1,349	540	15.5	(18)+45

Data source: Own calculations, based on data provided in annual reports of the three patent offices and on the Trilateral Statistical Report, 2008, and the WIPO annual report of 2008. (1) In Japan the search process is outsourced to external organisations, which makes 'per-examiner' comparisons irrelevant for searches. [5] and [7]: The share of patent applications for which a request for examination is filed is 100 percent at the USPTO; 94 percent at the EPO and 67 percent at the JPO. The share is smaller in Japan because the applicants can wait up to three years before requesting an examination. [6] and [7]; INC stands for the total number of claims included in patent applications, which are computed from the average number of claims per patent filed: 24 at the USPTO, 23 for total applications filed at the EPO (PCT international + EU Direct), 15 for patent applications at the EPO for which examination is required (including PCT regional); and 9 at the JPO.

The trends in workloads per examiner over the past 12 years are depicted in Figure 3. Comparing workloads is not straightforward: the JPO does not perform searches in-house and at the EPO one must clearly distinguish the workload for searches from the workload for substantive examination. At the USPTO both searches and examinations must be performed for all applications. Three observations can be drawn from Figure 3. First, the USPTO has always had the highest workload per examiner and the EPO the lowest, with the JPO being in an intermediate position. Second, a strong convergence between the EPO and the USPTO has occurred for

searches workloads. The USPTO has sharply reduced the average workload through the recruitment of nearly 2,000 new examiners between 2002 and 2007, whereas the EPO has constantly increased the 'search' workload of its staff. Third, despite the USPTO recruitment efforts there are still striking divergences in the 'examination' workload. The average EPO examiner has treated about 500 claims per year over the past 12 years, against more than 1,700 for the average USPTO examiner and 1,500 at the JPO.

Figure 3. Trend in the annual number of claims under search or under examination per examiner, 1996-2008.



Source: Own computation from USPTO, EPO, JPO information on patent filings and average number of claims; and from the Trilateral Statistical Report for data on examination rates for the JPO and the EPO.

One explanation for this overwhelming difference in workloads is attributable to the average time spent by examiners on each patent, whereby smaller workloads would allow for longer pendency.[28] The EPO has the longest average pendency rate (63 months, or five years, made up of 18 months for the search report and 45 months for the substantive examination), which is

[28] Informal contacts suggest that a search for prior art is performed in less than 2 hours at the USPTO, against about 8 hours at the EPO (cf. Lemley (2001) for detailed data on the USPTO processes). For the examination process a US examiner spend about 13 hours per patent, against about 30 hours at the EPO. This is confirmed by the Federal Trade Commission (2003, chap. 5, p. 5) : an average application gets only about 15–20 hours of patent examiner time.

similar to the average pendency at the JPO (68 months, made up of 3 years allowed for the request for examination and 33 months of examination pendency), but much higher than the examination duration at the USPTO (35 months, all inclusive). It is worth mentioning that the relatively long pendency rate in Europe is endogenous and structural (rather than due to backlogs), for five reasons.

First, a slower process in Europe, or longer examination pendency, means that examiners spend more time on each patent application than in the USPTO (35 months) or the JPO (33 months). Assuming similar analytical skills, it can logically be inferred that EPO examiners' decisions are based on a more in-depth analysis of the application. This, in turn, would lead to a higher quality patent (i.e., higher rates of withdrawal or refusal), or a higher degree of rigour in the selection process.[29] Second, the fact that a patent is validated by three examiners (the "Division" described in the "examination skills" component, see OD.3.5), including a senior "chairman", requires more time than a patent granted by a single examiner. Third, as explained earlier (see OD.2.8) modifying the legal scope of protection associated with a technology is made through the adaptation of the priority filing in Europe, and through the filing of a new (CIP) filing in the US. The adaptive process at the EPO generates interactions and communications with the examiners, which logically generates delays. Fourth, applicants in Europe can easily request "oral proceedings", especially when the examiner intends to refuse the patent or request strong amendments to the patent.[30] This results in more rounds of exchange between the examiner and the applicant. Conversely, at the USPTO and JPO examiners routinely issue refusals whenever the reply of the applicant to the first examination report is not satisfactory. Fifth, applicants rely on various tools to delay the grant date, which is synonymous to high costs (translations, national validation fees and national renewal fees must be covered once the patent is granted).[31]

OD3.7. Post-grant opposition process allows third parties to challenge the validity of a patent up to nine months after the decision to grant. This process improves the actual quality of the European patent system: it is much less expensive than a patent litigation in court and allows third parties to produce new prior art or useful information against the validity of a patent. About five percent of granted patents are currently opposed at the EPO. The US and Japanese systems do not have an opposition process, which means that challengers bear the burden of very high litigation costs (cf. Graham et al. (2002), Graham and Harhoff (2006) and Maskus (2006) for qualitative and quantitative arguments in favour of the instalment of a reasonably priced post-grant opposition process at the USPTO).[32]

---

[29] Lazaridis and van Pottelsberghe (2007) show that nearly half of the withdrawals can be considered as being induced by the work of EPO examiners, because they occur just after a communication from the EPO.

[30] This is the "right to oral proceeding" defined in Article 116(1) of the EPC and the "right to be heard" defined in Article 113(1).

[31] The tools used to delay the grant date are listed in Stevnsborg and van Pottelsberghe (2007). For instance, Lazaridis and van Pottelsberghe (2007) show that one communication between the examiner and the applicant induces one year of delay in the examination process, whatever its outcome (withdrawal or grant). Mejer and van Pottelsberghe (2010) provide evidence on the sharp increase in cost that follows the grant of a patent in Europe.

[32] Graham and Harhoff (2006)' welfare calculations suggest that the benefit from a post-grant review mechanism could be nearly $25 billion. The main parameter affecting this estimate is not savings on the cost of litigation, but the

- **LS4. Fee policies**

The fee policy in a patent system will influence its affordability, especially for small entities. Lax fee policies in the three patent offices seem to have contributed to the trend towards a higher propensity to file patents. Although still rarely considered as effective policy leverage, patent fees do matter. Recent quantitative evidence confirms that applicants' behaviour is influenced by the fee structure of patent offices.[33] In Japan entry fees (i.e., filing and search fees) have always been very low, virtually zero (cf. de Rassenfosse and van Pottelsberghe, 2008). In the US they have fluctuated between 500 and 700 USD PPPs, whereas Europe is slightly more expensive. For the fees up to the grant of a patent (filing, search and examination fees), Japan and the US have cumulated fees of about 2000 USD PPPs, against about 5000 USD PPPs in Europe. Over the past 15 years a downward trend in entry and cumulated fees up to the grant has probably encouraged the increase in patent filings at the EPO. The relatively low fees in Japan and the US partly explain the large number of patent filings observed in these two countries (cf. van Pottelsberghe and François, 2009).

An affordability index (fees divided by GDP per capita), which reflects the extent to which an inventor may be able to support the cost of patenting in its own country, is computed by de Rassenfosse and van Pottelsberghe (2010). It shows that the US is by far the most affordable patent system, and the EPO is actually the least affordable, with Japan being in an intermediate position. The authors also show that the US is the only country in the world where yearly renewal fees are actually lower than yearly application fees. In addition, yearly renewal fees actually decrease over time.

- **In a nutshell**

The qualitative analysis presented in this section is summarized in Table 3. In order to assess the broad (relative) levels of quality for the novelty and inventiveness legal standards, we have marked each component of their operational design on a relevance scale that goes from 1 to 3 (see Table 1). The 'relevance' scale indicates the extent to which the component matters to satisfy its legal standard, and the extent to which the information is easy to access. The column entitled "weight" provides the relevance level for each operational design's component. The

social costs of currently un-litigated patents that bestow excessive market power on some applicants. This market power either allows the patentee to extort licensing fees, or force competitors to invent around the respective patent.

[33] It could be argued that fees should not play an important role because they constitute only a fraction of total patenting costs (which include services provided by attorneys, drafting support, search for prior art). These costs are difficult to approximate (cf. van Pottelsberghe and Mejer, 2008) and are indeed substantial. Cf. de Rassenfosse and van Pottelsberghe (2010) for a survey of the studies that estimate the fee elasticity of patent. On average, the fee elasticity of demand for patents fluctuates around -0.3: an increase of 10 percent in fees would induce a drop in the demand for patent of about three percent.

quality scale of the three patent offices for each component is motivated by the arguments provided all along this section.

Table 3. Quality assessment of the 2 layers' patent system

	Weight[1]	USA	Japan	Europe
LS1. Patentable subject matters		***Many***	***Medium***	***Medium***
LS2. Search for prior art				
- OD2.1. Subject matters	2	1	2	2
- OD2.2. Ownership (F2F vs F2I)	1	1	2	2
- OD2.3. Identification of prior art	2	2	2	3
- OD2.4. Search report	1	1	1	2
- OD2.5. Language(s)	2	1	1	3
- OD2.6. Opposition process	3	1	1	3
- OD2.7. Grace period	1	1	2	3
- OD2.8. Controlled adaptability	3	1	3	3
- OD2.9. No hidden patents	2	1	3	3
Weighted sum of OD.2.x (USPTO=100)		***100***	***174***	***247***
Thoroughness of prior art identification		***Low***	***Medium***	***High***
LS3. Inventiveness				
- OD3.1. Novelty test	3	1	2	3
- OD3.2. Request of examination	2	2	2	3
- OD3.3. Definition of inventiveness	1	1	1	2
- OD3.4. Incentives	2	1	2	2
- OD3.5. Skills	3	1	3	3
- OD3.6. Low workload	3	1	2	3
- OD3.7. Opposition process	2	1	1	3
Weighted sum of OD.3.x (USPTO=100)		***100***	***178***	***250***
Rigour in inventiveness check		***Low***	***Medium***	***High***
LS4. Fees (pre- and post-grant)		***Low***	***Medium***	***High***
Broad selectivity (four legal standards)		***Low***	***Medium***	***High***
Impact on patent systems				
- Propensity to patent		High	Medium	Low
- Backlogs		High	Medium	Low
Patents in force in 2008 (millions)[2]		1.9	1.3	(0.51)
Claims in force in 2008 (millions)[2]		45.6	11.7	(7.7)

(1) Cf. Table 1 for a description of legal standards, the components of their operational design and the relevance level of these components for quality assessment. (2) The number of claims per patent is supposed to be 24 at the USPTO, 9 at the JPO and 15 at the EPO. Due to the fragmented patent system in Europe, counting all patents enforced would induce a large amount of double (triple) counts. The figure represents the number of patents enforced in Germany, where 95% of the EPO patents are validated after grant.

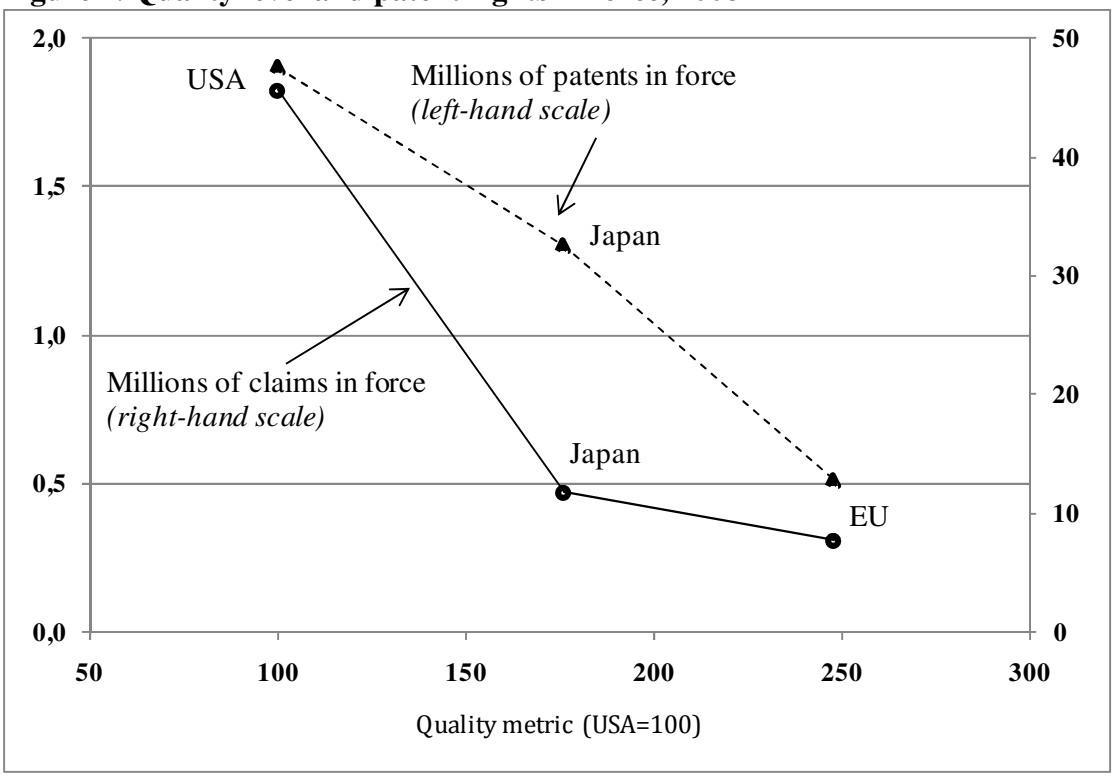
For instance, for the operational design of the novelty condition, the "ownership" component has a small weight of 1, because it is not the most relevant factor affecting quality in patent systems (the "first to file" system should stimulate applicant to display their invention faster, and reduce uncertainty in case of litigation). The opposition process and controlled adaptability have a weight of 3, because they play a key role in the examination process. With the former component third parties can submit new prior art, while the latter limits the possibility to adapt patents to existing technologies. For the operational design related to the inventiveness legal standard, the novelty condition, workload and education/experience of examiners all have a weight of 3, because we strongly believe that these components play a key role in the patent selection process.

In order to get a broad approximation of the degree of quality of the novelty and inventiveness legal standards, we compute the weighted sum of the ranks obtained for the components of their operational design. The results were indexed with a USPTO base (USPTO=100). There might be a degree of subjectivity (self-assessment by the author) in allocating the weights. However, the fact that the un-weighted sums would lead to very similar results ease this potential source of bias. Similarly, the logical elements used to rank the offices on a quality scale might be disputable and should be validated through a more in-depth empirical research. We however tend to believe that the arguments put forward in this section provide a fair assessment of the situation. Table 3 can be interpreted as follows. The quality of the examination process is substantially higher in Europe than in the USA, 250% higher according to our metrics, while Japan is in an intermediate position of 170%.

In the US, a relatively low quality or rigor of the examination process (due to a high turnover of examiners, a heavy workload per examiner, a soft identification of prior art, the lack of an opposition process) associated with low fees and the fewest number of restrictions on patentable subject matter, have probably led to a very high propensity to patent (it is easy and inexpensive to get a patent granted). Even if this indicator is subject to some measurement errors, the USPTO's corrected grant rate of 87-97 percent makes it the most 'applicant-friendly'. This high propensity to patent probably has induced enlarged backlogs. At the opposite is Europe, where a thorough identification of prior art associated with a high rigour of the examination process and high fees have led to a relatively low demand for patents and a much less worrying backlog. Japan is in an intermediate position. For some components of its operational designs it is closer to the US, and for others it is closer to Europe.

The ultimate consequence of these heterogeneous degrees of quality across patent systems can also be gauged through the number of patents (or claims) in force in the three geographical areas. Figure 2 depicts the relationship between the degree of quality in a patent system and the number of patents (or claims) in force. Nearly 2 million patents (46 million claims) are in force in the USA, against 0.5 million (8 million) in Europe. Japan is in an intermediate position, with 1.3 million patents in force (12 million claims). In other words, the lower the degree of quality in a patent office, the higher the number of patent – of questionable legitimacy- in force in the system.

Figure 2. Quality level and patent rights in force, 2008



Source: cf. Table 3. The quality metric on the horizontal axis shows the average position for the two quality metrics (novelty and inventiveness' operational designs) presented in Table 3 (USPTO=100; JPO=176; EPO=248). The vertical axes show the number of granted rights in force: number of patents on the left-hand side and the number of claims on the right-hand side. Since there is no European Union patent (an EPO granted patent must be enforced at the country level), the number of patent in force in Germany are taken into account (95% of EPO granted patents are validated in Germany) as a proxy for Europe.

5. Concluding remarks

This paper argues that a systemic approach must be adopted in order to compare quality across patent systems. So far, economic analyses of quality in patent systems have frequently relied on ill-defined concepts of "strength" or "breadth". Whereas these two concepts are useful for theoretical modelling they have rather limited concrete policy implications. In addition, output rates like grant rates or litigation rates can be biased by the filing behaviour adopted by applicants and are hardly comparable across countries, precisely because of the systemic differences.

The objective of this paper was therefore to put forward a new methodological framework that takes into account the systemic dimension of patent systems. The concept of quality is defined as the extent to which patent offices comply in a transparent way with the main legal standards that

rule patentability conditions in their jurisdiction. The methodology consists in setting up a two-layers analytical framework composed of "legal standards" (first layer) and their "operational design" (second layer). Four legal standards are taken into account: subject matter, novelty, inventiveness and the fee schedule. Patent offices have similar codified rulings related to the novelty and the inventiveness requirements. Therefore, an in-depth analysis of the operational designs put in place to comply with these requirements must be performed in order to assess quality. Several components of the operational designs of the novelty and inventiveness requirements have been identified. These components vary in relevance (from 1 for a low relevance to 3 for a high relevance) and are used to compare patent offices on a likkert scale (from 1 for a low contribution to the selection mechanism and a weak transparency to 3 for a high contribution and strong transparency). This new methodological approach leads to two main conclusions and one policy implication.

First, a country's legal standards and the components of their operational design interact with each other and form a coherent system. For instance, a soft identification of prior art (or incomplete search report for the novelty legal standard) may logically undermine the inventiveness legal standard. To a similar extent, the patentability of controversial subject matters (e.g., business methods) will reduce the quality of search reports because prior art is not accessible or imperfectly codified. Further research should aim at validating the list of components that should be taken into account to characterize the operational designs, their level of relevancy, and the rating of patent offices. We however strongly believe that the selected components and their assessment provide a fair preliminary approximation of quality in patent systems.

Second, the analysis of three major economic areas (Europe, the USA and Japan) underlines strong international differences in the extent to which patent systems fulfil their objective. The patent selection process performed at the USPTO is less rigorous and transparent than at the EPO, as witnessed by a soft and flexible identification of prior art and a smaller degree of inventiveness. This lower rigour, coupled with very low fees, has led to an unmatched and unprecedented number of yearly applications and patents (nearly 50 million claims) of dubious quality being currently in force over the US market. The divergences appear less with the legal standards that set the patentability conditions than with their operational design, which include for instance the education and experience of examiners, their incentives, their workload, and several operational routines like the request for examination, the opposition process, the publication of the search report, or the easiness to adapt the scope of protection through claim-changes or the filing of continuation in parts. In Europe, more restrictions on patentable subject matters, a much higher rigour in the identification of prior art, a stricter evaluation of inventiveness, and high fees, translate into more than twice less patent applications than at the USPTO and much less patents being in force over the market (about 8 million claims). Japan is in an intermediate position.

Gallini (2002) attributes the drop in patent standards largely to "*the sharp rise in [patent] applications on products and processes in new subject areas for which the U.S. Patent and*

Trademark Office has limited expertise or access to prior art". This idea is surely grounded, but the reverse causality is probably even stronger: lower standards would induce more applications, because it is easier to be granted. A vicious cycle would therefore take place where lax patent standards would induce more applications, which in turn would further reduce quality standards through overloaded examiners. This is actually the main hypothesis put forward by Jaffe and Lerner (2004) to explain the 'broken' patent system in the US: policy makers at large (politicians, patent offices, judges) would have designed a patent system in such a way that its current plight became inevitable.

One important policy implication concerns the current attempts to converge towards a global patent system, whereby patent offices would enter into work sharing and eventually a mutual recognition process: A patent granted by office Y would be automatically granted by office Z. We are not there yet but the journey has started. This is witnessed by the growing number of bilateral Patent Prosecution Highway (PPHs) pilot projects signed and operated by the USPTO, the JPO, the EPO and several other national patent offices. Under the PPHs, a patent office Z which receives a search report or examination report made by patent office Y must perform its own search and examination reports much faster than for a regular application. Needless to say, this work sharing process (embedded with some sort of mutual recognition) can harm the patent system of country Z if the degree of quality in patent office Y is manifestly lower. This issue is particularly binding for the EPO examiners who bear the legal duty to perform a relevant search report themselves.

As long as quality of the examination process is not harmonised amongst the USPTO, the EPO and the JPO, or as long as their operational designs diverge, it can fairly be argued that moves towards global work-sharing and mutual recognition agreements might actually drive global patent quality down towards the lowest quality level available. Before entering into mutual recognition processes, patent offices should first converge in their operational design, which requires tackling painful questions related to examiners' incentive, their education, training and workload, not to mention the setting up of a post grant opposition process, an intermediate request for examination, the adoption of a "first to file" system, or the degree to which patent applications can be adapted during the examination process through continuation in parts or divisional applications (i.e. controlled adaptability).

It is tempting to end these concluding remarks with a well known motto symptomatically found in the email signature of an examiner: "*Patents should draw a line between the things which are worth to the public the embarrassment of an exclusive patent, and those which are not. Patents are, after all, government-enforced monopolies and so there should be some 'embarrassment' (and hesitation) in granting them*" Thomas Jefferson (1794).[34] It is tempting because it illustrates the importance, in the eyes of a former president of the United States, of deploying a rigorous examination process for a sound patent policy. An opposite viewpoint was advocated by Mark Lemley (2001), with its "*rational ignorance*" argument, whereby patent offices should not devote

[34] Michael Murer, Examiner on Sporting Goods, European Patent Office, in an email received on March 31, 2010.

too much resource in examination because only a few patents are worth it, and these will be properly assessed in litigation proceedings. The economic literature provides little insight about the optimal degree of quality or rigour that should prevail in a patent system. The two extreme levels of quality could actually be detrimental to innovation. This paper aimed at contributing to that debate by developing a methodological framework that allows assessing and comparing quality across patent offices. Our findings suggest that the EPO is closer to Jefferson's warning, whereas the USPTO is closer to the "*rational ignorance"* pathway. Yet, one does not know whether Europe is already too low on the quality ladder or whether the US is still too high.

References

Archontopoulos E., D. Guellec, N. Stevnsborg, B. van Pottelsberghe de la Potterie, and N. van Zeebroeck, 2007, When small is beautiful: Measuring the evolution and consequences of the voluminosity of patent applications at the EPO, Information Economics and Policy, 19(2), 103-132.

Arora A., A. Fosfuri, and A. Gambardella, 2002, Markets for Technology: The Economics of Innovation and Corporate Strategy, MIT Press.

Barton J.H., 2000, Reforming the patent system, Science, 287(5460), 1933-1934.

Barzel, Y., 1968, Optimal timing of innovation. Review of Economics and Statistics, 50, 348-355.

Bessen J. and M. J. Meurer, 2008, Patent Failure: How Judges, Lawyers and Bureaucrats Put Innovators at Risk, Princeton, NJ: Princeton University Press.

Caillaud B. and A. Duchêne, 2009, Patent Office in innovation policy: Nobody's perfect, Paris School of Economics, Working Paper, 2009-39.

Chang H. F., 1995, Patent Scope, Antitrust Policy, and Cumulative Innovation, The RAND Journal of Economics, 26(1), 34-57.

Chesbrough H., 2003, Open Innovation: The New Imperative for Creating and Profiting from Technology, Harvard Business School Press, pp. 227.

Claessens S. and L. Laeven, 2003, Financial Development, Property Rights, and Growth. Journal of Finance, 58(6), 2401-2436.

Cockburn, I. M., S. Kortum, S. Stern. 2002. Are All Patent Examiners Equal? The Impact of Examiner Characteristics. NBER Working Paper Series, w8980.

Cornelli, F., Schankerman, M, 1999. Patent renewals and R&D incentives. The RAND Journal of Economics, 30(2), 197-213.

Danguy J., G. de Rassenfosse, and B. van Pottelsberghe de la Potterie, 2009, The R&D-patent relationship: An industry perspective, EIB Papers, No 7/2009.

Danguy J. and B. van Pottelsberghe de la Potterie, 2009, Cost-benefit analysis of the community patent, Bruegel Working Paper, 2009/08.

de Rassenfosse G., 2010, How much do we know about firms' propensity to patent and should we worry about it? ECARES Working Paper, forthcoming.

de Rassenfosse G., and B. van Pottelsberghe de la Potterie, 2007, Per un pugno di dollari: A first look at the price elasticity of patents, Oxford Review of Economic Policy, 23(4), 588-604.

de Rassenfosse G. and B. van Pottelsberghe de la Potterie, 2008, On the price elasticity of demand for patents, ECARES Working Paper, 2008-031.

de Rassenfosse G. and B. van Pottelsberghe de la Potterie, 2009, A policy insight into the R&D-patent relationship, Research Policy, 38(5), 779-792.

de Rassenfosse G. and B. van Pottelsberghe de la Potterie, 2010, The role of fees in patent systems: theory and evidence, ECARES Working Paper, forthcoming.

Dernis, H., D. Guellec and B. van Pottelsberghe de la Potterie, 2001, Using patent counts for cross-country comparisons of technology output, STI Review, 27, OECD, Paris.

Dewatripont M. And P. Legros, 2008, "Essential" patents, FRAND royalties and technology standards, ECARES Working Paper 2008_010.

Encaoua D., D. Guellec, and C. Martínez, 2006. Patent systems for encouraging innovation: Lessons from economic analysis. Research Policy, 35(9), 1423-1440.
EPO, 2007, Scenarios for the future, How might IP regimes evolve by 2025? What global legitimacy might such regimes have?, EPO, 125 P.
EPO, 2010, Guidelines for examination in the European Patent Office, European patent Office, April, Munich, 597 p.
Farrell, J. and C. Shapiro, 2008, How strong are weak patents?, American Economic Review, 98(4): 1347–69.
Federal Trade Commission. 2003. To Promote Innovation: The Proper Balance Between Competition and Patent Law and Policy. http://www.ftc.gov/os/2003/10/innovationrpt.pdf.
Franzoni C. and G. Scellato, 2010. The grace period in international patent law and its effect on the timing of disclosure. Research policy, 39, 200-213.
Friebel G., A. Koch, D. Prady and P. Seabright, 2006, Objectives and incentives at the European Patent Office. Centre IDEI – Institut d'Economie Industrielle, Université de Toulouse.
Gallini, N., 1992. Patent policy and costly imitation. The RAND Journal of Economics, 23(1), 52-63.Ginsburgh V., 2005, Languages, Genes, and Cultures, Journal of Cultural Economics, 29 (1), 1-17.
Gallini, N., 2002. The economics of patents: Lessons from recent U.S. patent reform, Journal of Economic Perspectives, 16(2), 131-154.
Geuna A. and L. Nesta, 2007, University patenting and its effects on academic research: The emerging European evidence, Research Policy, 35(6), 790-807.
Gilbert, R., Shapiro, C., 1990. Optimal patent length and breadth. The RAND Journal of Economics, 21(1), 106-112.
Ginarte J. and W. Park, 1997. Determinants of patent rights: A cross-national study, 26(3), 283-301.
Glazier, 2000, Patent Strategies for Business, Third Edition, LBI Institute, Washington DC, 420 p.
Graham S. and D. Harhoff, 2006, Can post-grant reviews improve patent system design? A twin study of US and European patents, CEPR Discussion Paper 5680, 29 p.
Graham S., B. Hall, D. Harhoff and D. Mowery, 2002, Post-issue patent 'quality control': a comparative study of US patent re-examinations and European patent oppositions, NBER Working Paper No. W8807.
Grossman G. And E. Lai, 2004. International protection of intellectual property. American Economic Review, 94(5), 1635–1653.
Guellec, D. and B. van Pottelsberghe de la Potterie, 2000, Applications, grants and the value of patents, Economic Letters, 69(1), 109-114.
Guellec D. and B. van Pottelsberghe de la Potterie, 2007, The Economics of the European Patent System, Oxford University Press, Oxford, 250 p.
Guellec D., B. van Pottelsberghe de la Potterie and N. van Zeebroeck, 2007, Patent as a market instrument, Chapter 4, in Guellec D. and B. van Pottelsberghe de la Potterie, The Economics of the European Patent System, Oxford University Press, Oxford, pp. 85-113.

Hall B. H. and R. H. Ziedonis, 2001, The Patent Paradox Revisited: An Empirical Study of Patenting in the US Semiconductor Industry, 1979-1995, Rand Journal of Economics, 32(1), 101-128.

Harhoff D., 2008, Strategic patenting, innovation and competition: towards subprime patents?, Presentation prepared for the Jacquemin Seminar Series, Brussels – November 7th, 2008.

Harhoff D., 2009, Economic cost-benefit analysis of a unified and integrated European patent litigation system, EC DG Internal Market Report, 26 February, MARKT/2008/06/D.

Harhoff D., 2009b, How to compute grant rates, presentation at the EPO/OECD conference, Vienna, October.

Harhoff D., K. Hoisl, B. Reichl and B. van Pottelsberghe de la Potterie, 2009, Patent Validation at the Country Level – the Role of Fees and Translation Costs, 38(9), pp. 1423-1437.

Harhoff D., K. Hoisl and B. van Pottelsberghe de la Potterie, 2008, Languages, Fees and the International Scope of Patenting, ECARES Working Paper series, 2009_10.

Harhoff D., F. Scherer, and K. Vopel, 2003, Citations, family size, opposition and the value of patent rights, Research Policy, 32(8), 1343-1363.

Hegde D., D. Mowery, and S. Graham, 2009, Pioneering Inventors or Thicket Builders: Which U.S. Firms Use Continuations in Patenting?, Management Science, 55(7), 1214-1226.

Jaffe, A. 2000. The U.S. patent system in transition: policy innovation and the innovation process, Research Policy, 29(4-5), 531-557.

Jaffe, A., Lerner, J., 2004. Innovation and its discontents: How our broken patent system is endangering innovation and progress, and what to do about it. Princeton University Press, New Jersey, 236 p.

Kazenske, E. 2003. The future of prior art searching at the United States patent and trademark office, World Patent Information, 25(4), 283-287.

Klemperer, P., 1990. How broad should the scope of patent protection be? The RAND Journal of Economics, 29(1), 113-130.

Kortum S. And J. Lerner, 1999, What is behind the recent surge in patenting? Research Policy, 28(1), 1-22.

Langinier C. and P. Marcoul, 2009, Monetary and Implicit Incentives of Patent Examiners, May, Working Paper, University of Alberta.

Lazaridis G., and B. van Pottelsberghe de la Potterie, 2007, The rigour of EPO's patentability criteria: An insight into the "induced withdrawals", World Patent Information, 29(4), 317-326.

Lemley, M., 2001. Rational ignorance at the patent office. Northwestern University Law Review, 95(4), 1495-1528.

Lissoni, F., P. Llerena, M. McKelvey, and B. Sanditov, 2008, Academic patenting in Europe: new evidence from the KEINS database, Research Evaluation, 17(2), 87-102.

Mazzoleni R. And R. Nelson, 1998, The benefits and costs of strong patent protection: a contribution to the current debate, Research Policy, 27, 273-284.

Maskus K. E., 2006, Reforming U.S. patent policy : getting the incentives right, CSR 19, November, Council on Foreign Relations, USA, 45 p.

Mejer M. and B. van Pottelsberghe de la Potterie, 2009, Economic incongruities in the European Patent System, Bruegel Working Paper, 2009/01.

Mowery, D. and Sampat, B., 2004, 'The Bayh-Dole Act of 1980 and University–Industry Technology Transfer: A Model for Other OECD Governments? Journal of Technology Transfer, 30(1–2): 115–27.
Nordhaus, W., 1969. Invention, growth and welfare: A theoretical treatment of technological change. M.I.T. monographs in economics, 10, 168 pp., M.I.T. Press, Cambridge, MA.
NAPA -National Academy of Public Administration, 2005, U.S. Patent and Trademark Office: Transforming to meet the challenges of the 21st century, available at: http://www.napawash.org/Pubs/PTO-8-25-05.htm.
O'Donoghue T., 1998, A Patentability Requirement for Sequential Innovation, Rand Journal of Economics, 29(4), 654-679.
Peeters C. and B. van Pottelsberghe de la Potterie, 2006, Innovation strategy and the patenting performances of large firms, Journal of Evolutionary Economics, 16(1-2), 109-135.
Quillen, C. and O. Webster, 2001, Continuing patent applications and performance of the U.S. Patent Office, Federal Circuit Bar Journal, 11(1), 1-21.
Quillen, C., O. Webster, and R. Eichmann, 2002, Continuing patent applications and performance of the US Patent and Trademark Office - Extended, Federal Circuit Bar Journal, 12(1), 35-55.
Sampat B., 2005, Determinants of patent quality: an empirical analysis, working paper, Columbia University.
Scherer, F.M., 1972, Nordhaus' theory of optimal patent life: a geometric reinterpretation, American Economic Review, 62, 422-427.
Scherer, F.M., 2002. 'The economics of the human gene patents'. Academic Medicine, 77/12 part 2: 1348-1367.
Scotchmer, S., 1991. Standing on the shoulder of giants: cumulative research and the patent law, Journal of Economic Perspectives, 5(1), 29-41.
Scotchmer, S., 1999. On the optimality of the patent renewal system. The RAND Journal of Economics, 30(2), 181-196.
Scotchmer, S. and Green, J., 1990. 'Novelty and disclosure in patent law'. RAND Journal of Economics, 21/1: 131-146.
Seckelmann M., 2001, The Quest for Legal Stability: Patent Protection within the German Empire, 1871 – 1903, Max-Planck-Institute for European Legal History, EBHA Conference 2001: Business and Knowledge.
Shapiro C., 2007, Patent reform: aligning reward and contribution, Innovation Policy and the Economy, 8, 111-156.
Sherry E. and D. Teece, 2004, Royalties, evolving patent rights, and the value of innovation, Research Policy, 33(2), pp. 179-191.
Stevnsborg N. and B. Van Pottelsberghe de la Potterie, 2007, Patenting Procedures and Filing Strategies, in Guellec, D. and B. Van Pottelsberghe de la Potterie. The Economics of the European Patent System, Oxford: Oxford University Press, Oxford, Chapter 6, p. 155-183.
TMPDF, 2008, EPO future workload study; document CA144/07 – Comments by TMPDF: May 2008, ref PP05/08, Trade Marks, Patents & Design Federation, UK, London, 11p.
Teece D., 1993, Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy, Research Policy, 22(2), pp. 112-113.

van Pottelsberghe, B., 2009. Lost property: The European patent system and why it doesn't work, Bruegel Blueprint, Brussels, Belgium.
van Pottelsberghe de la Potterie B. and E. Archontopoulos, 2010, EU've got a message: policy learning from the RIM-NTP patent litigation, ECARES Working Paper, forthcoming.
van Pottelsberghe de la Potterie B. and D. François, 2009, The cost factor in patent systems, Journal of Industry, Competition and Trade, 9(4), 329-355.
van Pottelsberghe de la Potterie B. and M. Mejer, 2010, The London agreement and the cost of patenting in Europe, European Journal of Law and Economics, 29(2), 211-237.
van Pottelsberghe de la Potterie B. and N. van Zeebroeck, 2008, A brief history of space and time: the scope-year index as a patent value indicator based on families and renewals, Scientometrics, 75(2), May, 319–338.
van Zeebroeck N., 2007, Patents only live twice: a patent survival analysis in Europe, Working Papers CEB 07-028.
van Zeebroeck N., 2010, The puzzle of patent value indicators, Economics of Innovation and New Technologies, in press.
van Zeebroeck N., N. Stevnsborg, B. van Pottelsberghe de la Potterie, D. Guellec and E. Archontopoulos, 2008, Patent inflation in Europe, World Patent Information, 30(1), 43-52.
van Zeebroeck N., B. van Pottelsberghe de la Potterie, and D. Guellec, 2009, Claiming More: The increased voluminosity of patent applications and its determinants, Research Policy, 38(6), 1006-1020.
Weber Max, 1924, Wirtschaftsgeschichte. Abriß der universalen Sozial- und irtschaftgeschichte. Aus den nachgelassenen Vorlesungen herausgegeben von S. Hellmann u. M. Palyi, 2nd edition, Munich, Duncker & Humblot; Chapter 4.
WIPO, 2008a, World Patent Report – A statistical review, World Intellectual Property Organization, 72 p.
WIPO, 2008b, Standing Committee on the Law of Patents, Twelfth Session, Geneva, June 23 to 27, pp. 137.
Yamauchi I. and S. Nagaoka, 2009, Reforms of patent examination request system in Japan: some lessons, IIR Working Paper.
Yoshikawa, A. 1988. Japanese biotechnology: new drugs, industrial organization, Innovation and strategic alliance, Berkeley Roundtable of the International Economy.